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THE TECH ENGINEERING NEWS

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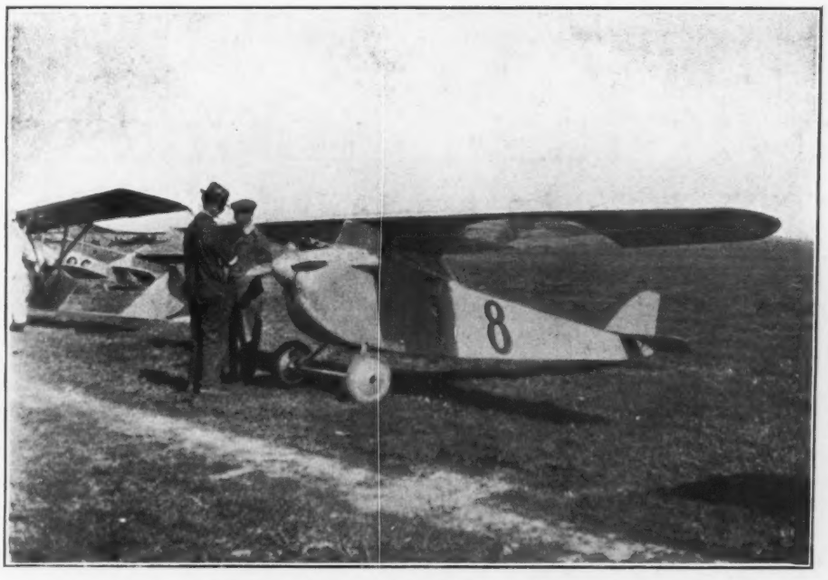
VOL. V. NO. 5

DECEMBER, 1924



A HENDERSON MOTORCYCLE ENGINED LIGHT PLANE

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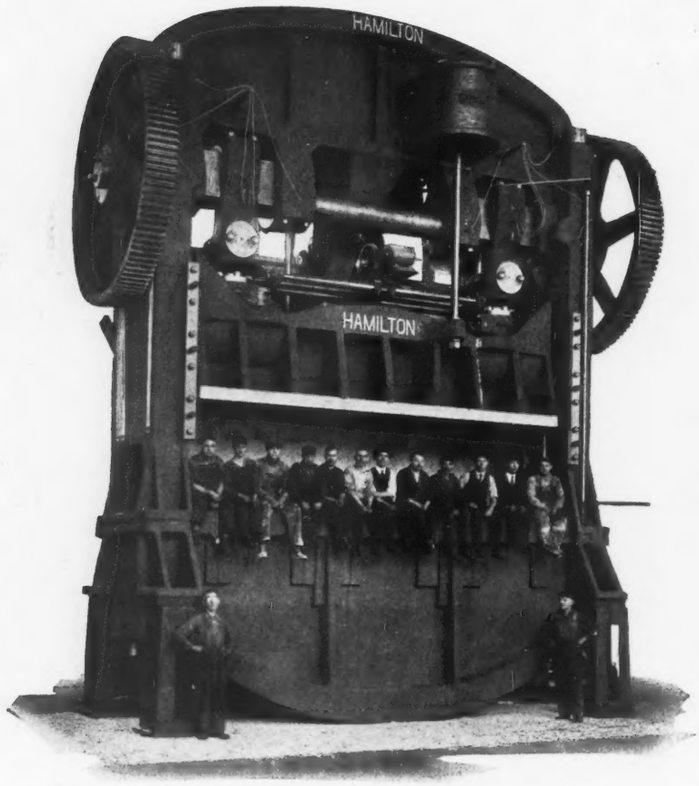

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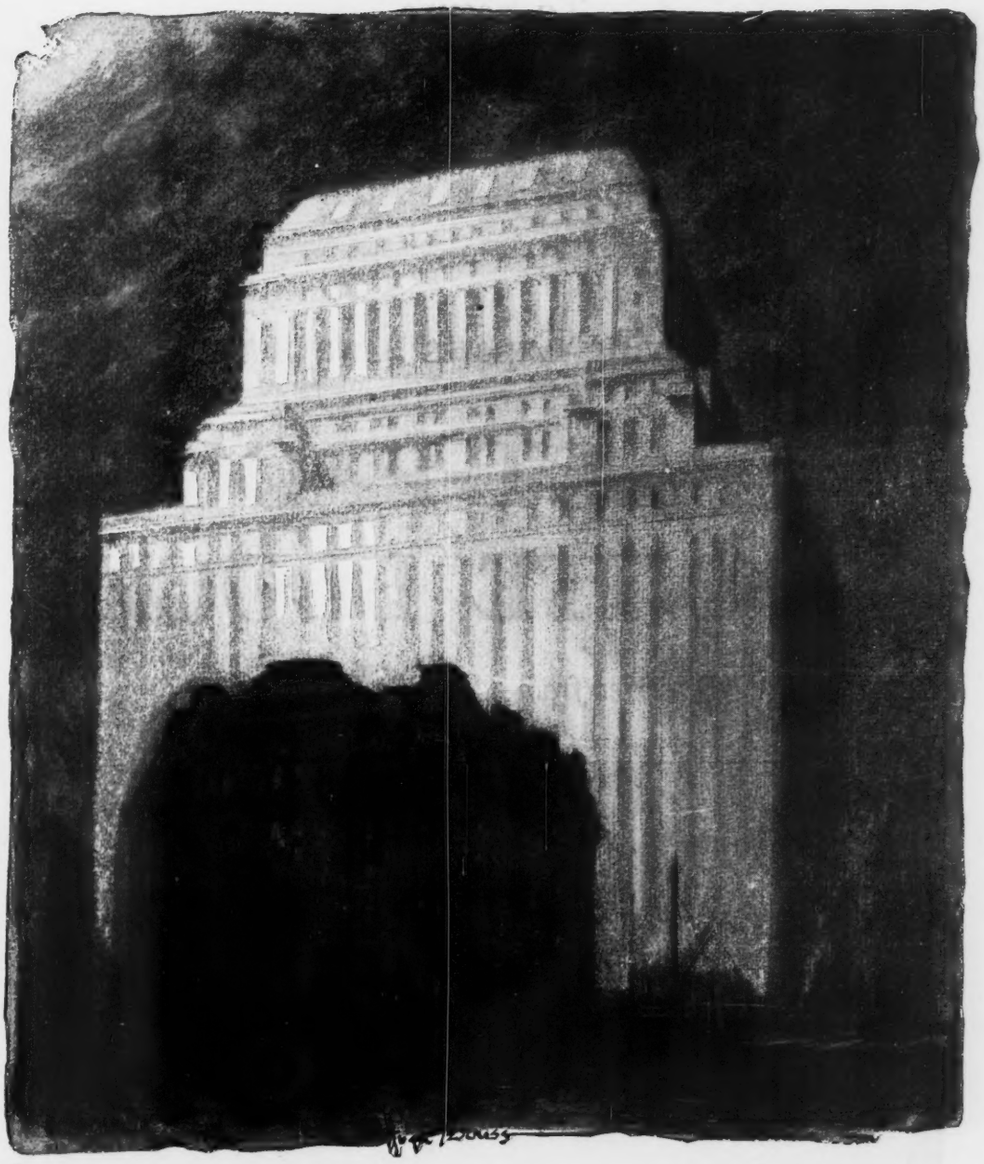

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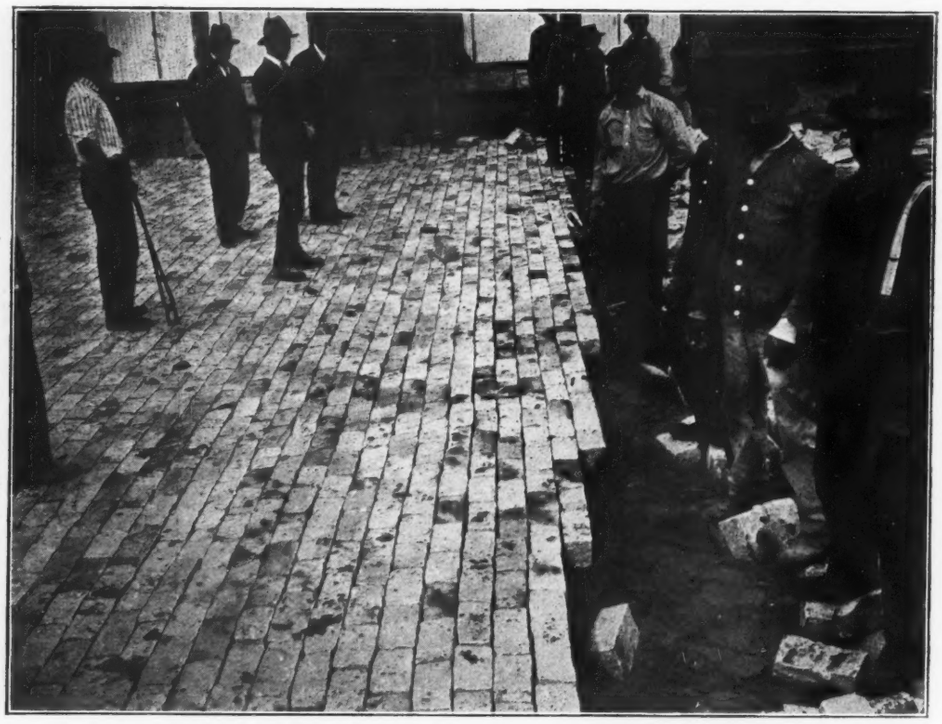

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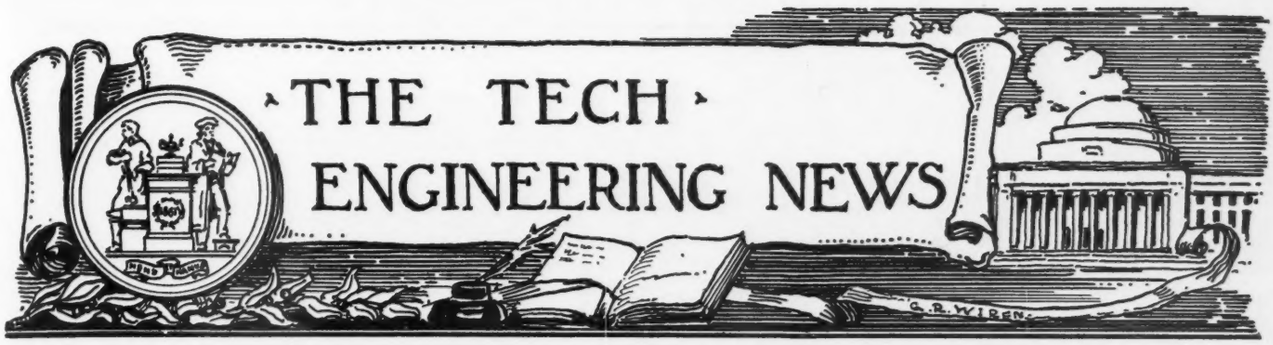

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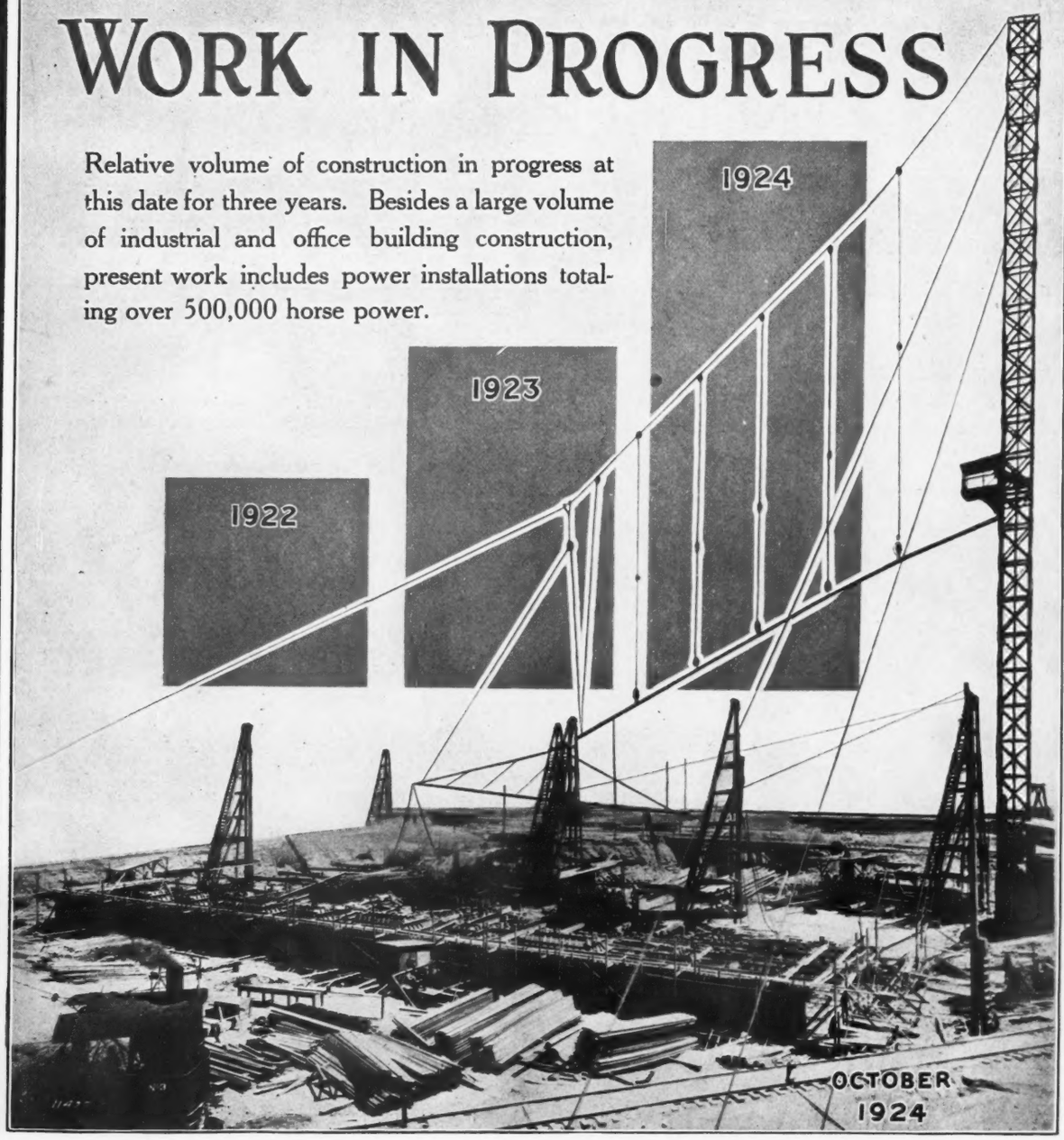
WORK IN PROGRESS

Relative volume of construction in progress at this date for three years. Besides a large volume of industrial and office building construction, present work includes power installations totaling over 500,000 horse power.



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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME V | DECEMBER, 1924 | NUMBER 5

THE SWIMMING POOL AND THE ENGINEER

By WILLIAM S. FRANKLIN, Sc. D.

Professor of Physics, Massachusetts Institute of Technology

EVERY thoughtful student of hygiene and sanitation is coming to look upon the swimming pool as hopelessly unclean even when disinfectants are used, and many of our clubs and colleges which are fortunate enough to have swimming pools are uncertain as to whether the value of the service, even assuming it to be above reproach in the matter of cleanliness, is a reasonable equivalent for the heavy capital and operation costs. Uncleanness and excessive cost are the outstanding facts, and it would seem that the swimming pool must be abandoned, except for small groups of the well-to-do, unless some method is devised which will give a very greatly increased degree of cleanness and at the same time lead to greatly reduced operation costs.

Usually, a first-class pool is supposed to be emptied, scrubbed and refilled once a week, and while the pool is in use the pool water is circulated through a filter at a rate sufficient to turn over the contents of the pool in 24 hours. Indeed, it has been thought that the *ideal* way would be to empty, scrub and refill a pool every night and circulate the pool water through a filter as above specified.

A study of the swimming pool problem leaves one with the conviction that pool design and operation has never been carefully considered as an engineering problem. Many of our indoor pools are pleasing in appearance, and if the water is to stay in the pool for weeks and be sterilized by chlorine the cost of operation will be reasonably low; but if the pool is to be frequently emptied, scrubbed and refilled, the cost of operation becomes prohibitive. Emptying, scrubbing and refilling take time and labor, the water for refilling is expensive and the cost of heating the new water for an indoor winter pool is excessive.

Having a pool full of polluted water we are, under existing circumstances, expected to run it into the sewer and buy fresh water; but let us consider the history of the fresh water. Two days previously, it was probably in a river flowing through a populous region and, a thousand times more filthy than our pool water, it had to be lifted several hundred feet and passed through a sand filter, and then distributed through a costly system of street mains. It is no wonder that the fresh water for a pool costs 7½ cents per thousand gallons! On the other hand the old pool water might be passed through a sand filter by lifting it three feet; the cost of this operation, including labor and interest and depreciation on cost of filter bed, can be made less than one-half cent per thousand gallons, and the water thus treated is already warm!

> *"Scarcely more than a generation ago every American boy came under the spell of hunting and fishing — and there is no more powerful incentive to laborious days—nor any anodyne so potent for bodily discomfort and hardship! A hunting and fishing boyhood; such has been the chief source of human energy in this lazy world of ours, the chief basis of life-long habit of persistent and strenuous effort; and the problem of educational play is to a great extent the problem of finding an effective substitute for the lure of the wild for stimulating young people to intense activity.*
>
> *"A ball field and a swimming pool are, next to his food, the most important thing for our boy Bill; and they would do more to make him into an energetic and industrious man than all the rest of his school work put together." From "Play as a Training in Application," "Bill's School and Mine."*

A very serious limitation in existing practice is the use of absurdly small capacity commercial filters. Indeed, it seems that the only type of filter that has been thought of for the swimming pool is the semi-portable filter which can be fabricated and sold like a steam boiler or engine. A well-known college swimming pool has such a filter which requires a pump lift of 20 feet and it will pass the entire contents of the pool in 24 hours of continuous operation; whereas, this same pool had a rectangular space alongside of it half as large as the pool which had to be filled with earth for a foundation for the pool platform, this rectangular space could have been converted into a standard type of sand filter at less cost than the cost of the fill and the cost of the commercial filter, this sand filter would have required a pump lift of only three feet, and it would have passed the entire contents of the pool in about eight hours!

A large-capacity sand filter is certainly a desirable adjunct to a swimming pool, and it is highly desirable to use a device to eliminate the mixing of the freshly filtered water with the old water in the pool and to automatically scrub the walls and bottom of the pool. Such a device cannot, of course, function while the pool is in use, but even a heavily patronized public pool is unused between noon and 2 P.M., and between 6 and 8 P.M., and with a filter bed twice as large as the pool, the entire contents of the pool could be turned over in two hours, so that the exact equivalent of "emptying, scrubbing and refilling" could be accomplished between noon and 2 P.M., again between 6 and 8 P.M. and again before 8 A.M., and pure water could be circulated through the pool at the two-hour rate while the pool is in use, from 8 A.M. to noon, from 2 to 6 P.M., and from 8 to 11 P.M. The usual college pool which is in use only during the afternoon, would require a filter bed only half as large as the pool so that the "emptying, scrubbing and refilling" operation could be carried out once a day, and fresh water could be circulated through the pool at an eight-hour rate while the pool is in use.

(Continued on page 186)

RECENT AERONAUTICAL EVENTS

By EDWARD P. WARNER, '17
Professor of Aeronautical Engineering, Massachusetts Institute of Technology

THE airplane and airship have claimed a very large part in recent history, as the newspapers record it. The Dayton race meet has revealed in a general way the present state of the art of airplane design in America, and something as well of the condition of commercial flying and the aircraft industry. The ZR-3 has crossed the Atlantic without incident, and the Shenandoah has forged her way steadily from coast to coast and back with a reassuring regularity. The continent has been spanned between dawn and dusk, and the circumnavigation of the globe by the squadron, headed by Lieutenant Smith, has left our pilots, like Alexander, sighing for more worlds to conquer. Public interest has been stirred to a high pitch, and the task before those who propagandize for flying is the conversion of the impersonal interest of a spectator into the enthusiasm and confidence which will lead the members of the lay public to make use of aircraft in their own business, where such use seems able to offer advantage. Public confidence is needed, and it is towards the instilling of confidence that efforts ought to be turned, if passenger-carrying by air, on a large scale, is to become a reality.

The meet at Dayton was the fifth of its line. The Pulitzer race was held there for the fifth time, and for the first time the National Air Races were marred by a fatal accident to a contestant. The collapse of Captain Skeel's airplane at the start of the Pulitzer race naturally shrouded the close of the week in gloom, and unfortunately also provided the occasion for a vast amount of uninformed comment and ill-advised criticism on the part of certain newspapers, which sought to make it appear that there had been dereliction of duty somewhere, and that the age of Captain Skeel's machine was in some way responsible for its failure. There has not been a scintilla of evidence to support such a claim.

On the whole, the races this year brought forth less that was new than in any preceding year, except in one particular class. For the first time since 1920 no new airplanes were constructed for the Pulitzer race, and in other events in which the army was entered, only standard service types, of which a number of identical examples were available, were sent to the starting line. Only the civilians presented experimental machines, and in the civilian classes, again with the one exception already intimated, there was a marked similarity of the entry lists to those of the preceding year at St. Louis. Some refinement had been made, engine powers had been increased, wings had been clipped still further in a few instances, but there was little evidence of really original design and construction during the past year. Among the most notable machines in the field was one which was not entered in any race, and accordingly never claimed its fair share of public attention, and another which power-plant troubles prevented from completing the course in the only event for which it had been possible to get the engine started at all.

The one shining exception was found in the light plane class. Design there had to be original if it were to exist at all, for no such thing as a light plane was known in America a year ago. The Wrights, to be sure, flew in 1903 with an engine of power low enough to get into the light plane class today, but power has steadily increased since that time. Service pilots now are prone to look with scorn on anything of under 200 horse-power, and hold engines giving less than twice that figure in some suspicion for really serious work, and the drop from the 1649 cubic inches of the Liberty, or even from the 510 of the smallest engine that has been used at all in previous race meets, to the 80 inches which was the limit set for the light plane races of this year administered a severe shock to accepted ideas.

The light plane is important in that it brings aviation back to the amateur. The airplane industry has followed a course not unlike that of the automobile, although the trend towards centralized production has been a little less evident. In 1902, and even as late as 1905, the lists of automobiles registered in the various states showed frequent recurrence under the heading "make" of the term "self," meaning that the owner had built his own car. The assembly of an automobile was a common amusement for amateur mechanics, but as time passed and the structures became more standardized, and the cars more efficient in their performance, the home-made vehicle faded out of the picture, and there probably are not a score of such cars among the 500,000 now registered in Massachusetts. It was the same with the airplane. In 1910 and 1911 amateurs all over the country were building machines and teaching themselves to fly. Many of the famous exhibition flyers of the time were self-taught, a considerable number of them on machines which they had themselves designed and constructed from the ground up. Special aviation meets

AN AERIAL TAXICAB

This plane is powered by an Anzani motor of 90 h. p. @ 4 cu. in. It was developed and entered in the Dayton Race Meet by the Yellow Aircab Company of Chicago.

were held for amateurs, and the lists of entries included names later to become and to remain famous in the airplane industry.

That condition began to change as early as 1912, and it came to a final termination with the coming of the war. The airplane had become too elaborate for the amateur. Its construction required too much machinery for the back-yard shop, and so many different kinds of mechanical skill that no one man was likely to be master of all. Concentration of the production of aircraft into the hands of a few large factories owned by corporations was the order of the day.

The light plane promises to bring another change in the opposite direction by simplifying the process of building an airplane to the point where the individual with limited financial resources and still more limited equipment can hope to engage in it. Of the nine light planes entered at Dayton, seven appeared at the starting line. Not one of the seven was built by a factory regularly engaged in the production of airplanes on any considerable scale, and all except two were the product of the work of individuals, or of small groups of individuals, with no organization of any sort behind them. Two of the builders were aeronautical engineers by profession, while another pair were airplane mechanics.

One-man jobs as they were, most of the light planes flew extremely well. All appeared to handle nicely in the air, and all had ample speed and climb, but all alike suffered acutely with engine troubles, and never had a real chance to show their merits. Forced landings were so frequent that they finally became humorous. In one fifty-mile race every machine entered which got through the first 10 miles at all had at least two forced landings due to engine failure, and the competition became one in the speedy location and cure of power plant difficulties, rather than of speed in the air. The proclamations of the announcer, fortified by a myriad of loud speakers, that: "Plane X has had a forced landing. The pilot is working on his carburetor" first grew monotonous, and then provocative only of mirth.

It became very plain to every spectator at the Dayton meet that the future of the light plane should be both important and interesting, but that it will be conditioned entirely on the development of an engine of reasonable reliability. The complete unfitness of the motorcycle engine for aeronautic service was plainly evident, and was the more startling when it stood out in contrast with the beautiful regularity with which the large

THE SNYDER-MACREADY LIGHT PLANE

This plane was one of the nine light planes entered in the Dayton Race Meet.

airplane engines ran. The airplane engine designer has uncomplainingly accepted a great deal of abuse in the past, but, as a matter of fact, his achievements in the field of reliability, as well as in reduction of weight, have been nothing less than marvelous. The running of an airplane engine for 300 hours at full power without overhaul is equivalent to operating an automobile on the road under ordinary conditions for at least 25,000 miles, without so much as grinding a valve, and the rarity of such a performance by a road vehicle hardly needs to be emphasized. Readers interested in motorboat racing will remember how, in the years before the war, it was rather exceptional for half of the boats entered to finish a race, and how sudden was the improvement when high speed marine engines were replaced by airplane models, which started at command, ran until the switch was thrown off or the gasoline exhausted. No one now thinks of using for speed-boats any other type of power plant than one closely based on aeronautical practice.

While the airplane engine has been administering an object lesson to the automobile designer and invading the marine field, the prospective demand for engines for light airplanes has passed unnoticed. It has been left for the motorcycle manufacturer to fill, with the unfortunate result already dilated upon. The same ingenuity which produces the Liberty and its more recently designed rival will, however, suffice, if turned in that direction, to create light plane engines giving 15-horse-power with a piston displacement of 45 cubic inches and on a total weight not exceeding 50 pounds, and if that is done within the next year the number of light planes built in 1925 should triple that for 1924.

The Institute has been represented, through a former student, in all the progress that has been made in the introduction of the light machine in this country, for Mr. Edumund T. Allen, one of the warmest protagonists of flight with minimum power and constructor of a light plane which has recently flown successfully with an engine of only 37 cubic inches piston displacement, probably the lowest-powered engine that has ever taken an airplane off the ground in America, was formerly enrolled in Course II, and was the pilot in France and Germany of the gliders built by the student Aeronautical Engineering Society, two and a half years ago.

Of the other extreme of speed and power, represented by the Pulitzer race, there is little to be said. Three of the machines entered at Dayton had been built at least two years ago, and the fourth was a standard pursuit type very much slower than the others. Even quite aside from the accident to Captain Skeel, the results left a spectator in considerable doubt as to the advisability of continuing unlimited racing. The cost of the machines and the hazard to the pilots seemed to more than over-weigh the advantages that accrue in possible improvements of the airplane and its engine. The offering of a thrill to a crowd of spectators can hardly be considered as an advantage. It has been

(*Continued on page 198*)

THE INSTITUTE OF OPTICS AT PARIS

By DR. CHARLES FABRY
Professor of Optics, University of Paris

THE progress of industry in its present condition is dependent upon scientific research. This is true in a varying degree for all the branches of industrial activity, but the industry of optics is in closer connection with science than any other.

It is impossible to be successful in building an optical instrument and even as common a thing as a photographic lens, in an empirical manner. The number of parameters (radii of curvature of the three or four lenses which make up the photographic lens, thickness of these lenses and distances at which they have to be placed, indices of refraction and dispersion of the glass) is too great to arrive at a satisfactory result by empirical trial. A mathematical study alone can produce the result, and this study is difficult when one desires to obtain the precision really necessary. The construction of an optical instrument thus becomes a difficult mathematical problem.

When the mathematician has finished his task, one must begin building. The raw materials consist of the different kinds of glass whose properties (indices of refraction, dispersion and absorption) have to be known with a precision which is required in almost no other industry, because an error of only a few units in the fifth decimal of any of the indices may be a troublesome influence on the quality of the instrument. Then, the form prescribed by the mathematician must be given to those glasses with an accuracy which exceeds by far that required in the most precise mechanical construction; for instance: a plane surface cannot be considered as *perfect* if it deflects from a plane by 1/10000 of a millimeter. Very accurate means of verification have to be employed.

In the optical industry, a commercial difficulty is added to these technical ones. The majority of optical shops are rather small firms, and cannot afford a large research laboratory. It is, therefore, necessary that they be aided by collective support on the part of the respective governments and by the scientists who cannot go without optical instruments of the best grade.

Such circumstances gave rise in France, after the war, to the idea of an optical institute. This plan could not be carried out immediately, as more urgent reconstruction work was at hand. It was only three years ago that the Optical Institute began to function with modest resources, in a temporary building. The object was to help the optical industry by all possible means; theoretical and experimental research of general interest; measurements and research requested by industry; training of optical engineers; forming of good workmen able to become shop superintendents.

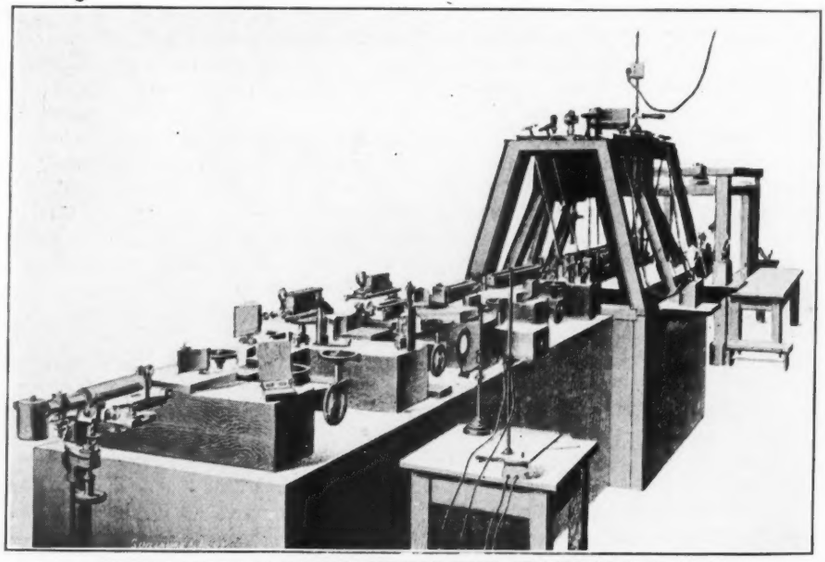
This program led to the establishment of three different sections in the Optical Institute:

1. Upper School for the optical engineers.
2. Professional School for the workmen.
3. Laboratory for research and experimentation.

Upper School. The students entering the Upper School have already had a good training in mathematics and a general instruction in optics. The duration of the course is one year, including a general course on optics (twelve lectures at the beginning of the year), course on the calculation of optical systems (two lectures per week during the entire year with practical application), a course on the construction of optical instruments (two periods per week), a course on the design and mechanical construction of instruments (two periods per week). Besides this there is a series of lectures on special subjects given by highly qualified persons selected outside of the staff of the Optical Institute (spectroscopy, photometry, properties of photographic plates, use of astronomical instruments, X-ray).

The students perform numerous measurements in the laboratory and, besides, there is a very close association between the Upper School and the laboratory. If a student shows ability for research, he may be authorized, if he so desires, to volunteer for some of the work carried out in the laboratory. The students of the upper school also devote a few periods to glass blowing in the shop, not in the hope of becoming good workmen (which would require too much time), but to become familiar with the difficulties of the art.

The number of students has been until now about ten each year. They come from different organizations, and are of different ages. Some are ordinary students belonging to the University of Paris where credit for the work done at the Optical Institute is allowed to them for "licencee;" others are older men and already belong to the optical industry, being allowed by their firms to devote part of their time to study. They can, if they desire, distribute their work over two or three years. These students are the most interesting, as they come to the Institute with practical knowledge, and what they learn at the Institute can be put into immediate application in a shop where they are already known. In some cases this method of instruction has given extremely good results, and I would be able to name at least two firms where the anti-



APPARATUS FOR MEASURING THE STANDARD METER
This apparatus was used by Dr. Fabry to measure the standard meter in monochromatic wave length.

scientific spirit prevailed, which have been greatly impressed by the influence of an employee who had been allowed to follow the instruction at our Institute.

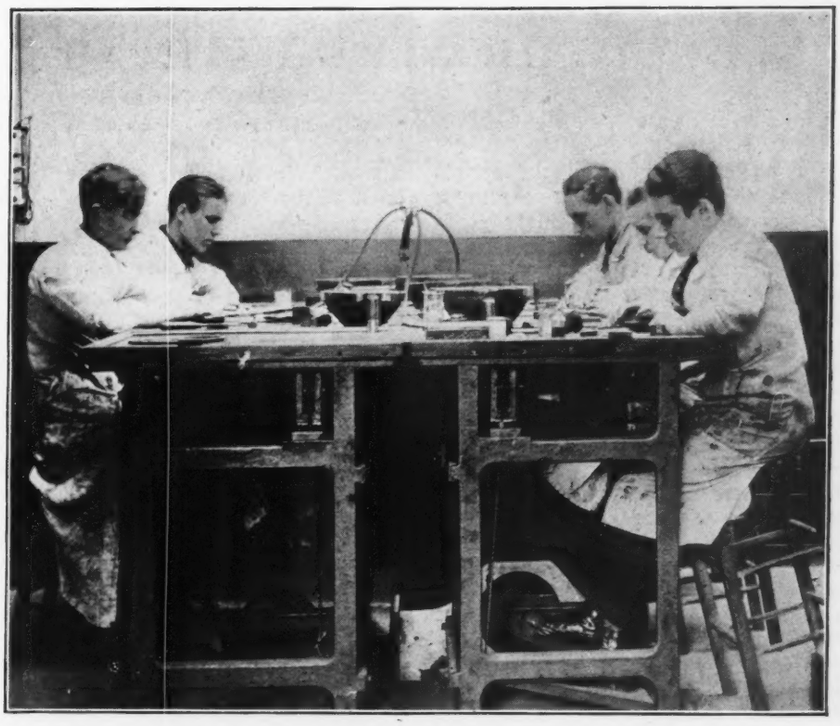
Finally, the government sends every year one or two army and navy officers who are qualified to specialize in optical questions. This method of procedure has been followed for the study of electricity for a long time.

Professional School: The Professional School has for its object the development of intelligent and educated workmen for the optical industry, with the hope that those who show ability in directing other men, could become good shop superintendents.

The question of training workmen is at the present time in a critical stage in France as well as, perhaps, in other countries. The directors of industry do not like to have in their shops apprentices who cause loss of time and material. Moreover, laws which have been made with a great deal of justice, protecting child labor, force the employer who hires children in any capacity to submit to a rather strict supervision on the part of the state authorities. A decrease in the quality of trained workmen has resulted during the past years, and to this has been added the very serious fact that a great number of children remained idle from the time they left the primary school until they entered the shop as adults. A strong movement has arisen for forming apprentice schools where the different trades would be taught. A great number of such schools have already been started by the government under the name of "Practical Schools of Industry." No optical school existed on account of the special character of this industry. It was found advisable to include such a school in the scientific institute, namely, the Optical Institute.

The apprentices enter the school at the age of about fourteen years, and the duration of their course is three years,—the school is free for all French pupils. Their time is about equally divided between the work in the shop and the work in the class rooms (French, elements of mathematics, drawing, elements of physics, optics).

The joining in the same institute of the instruction for workmen, higher instruction, and scientific research, has given rise from the beginning to a great deal of discussion, and I, too, was not very favorable to the idea at first. However, a three-year experience there allows me to say that this joining has shown itself very useful. The scientific section has benefited greatly by having on hand a good shop where the optical parts which were necessary could be constructed almost at once; the Optical Institute would not have had enough resources to have this shop if the professional school had not rendered it indispensable. On the other hand, the daily contact between the scientific men and the manual workers has shown itself very useful for the latter. The workman when left to himself has always a tendency towards routine, but when one shows him, for instance, instruments allowing easy and precise verification, it is found that he refuses to use any other. This is what happened with our workmen who have become very rapidly accustomed to the accurate laboratory methods.



INSTITUTE FOR TECHNICAL AND APPLIED OPTICS AT PARIS
Students learning to grind lenses.

In connection with the Professional School we have organized courses for adult workmen mainly in order to give them the general knowledge in optics which is too often wanting.

We have also started courses for optical salespeople, who generally have no great knowledge of optics and optomology.

Research Laboratory. The Research Laboratory was occupied at first with measurements requested by industry. Those requests were very few in the beginning, but have greatly increased in number, and some of them have led to the development of new methods.

In optics many of the measurements come down finally to measurements of angles and length. A goniometer reading to two seconds of one degree, built by A. Jobin, is used for the measurement of angles; a longitudinal comparator built by E. Bouty, provided with a divided rule which has been examined by the Bureau International des Poids et Mesures, is used as the basis for the measurements of length.

The most frequent measurements were at first a measurement of indices, of defraction and absorption, either on raw samples which could be cut into prisms, or on existing samples which could not be destroyed. A new method has been studied for the measurement of indices in the ultraviolet. All the methods for the verification of surfaces have been used (use of spheres, method of Foucault, method of Hartmann, method of Michelson). A new method has been devised for the study of aberration in completed optical apparatus. The precise measurement of radii of curvature, of the measurement of dilatations, have led to extensive research. The absorption of the radiations by glass, the measurement of their birefringence, the verification of the sextants, the verification by interference of ball bearings, have also been the occasion for interesting researches.

Optical Review: A new review was founded three years ago under the auspices of the Optical Institute. It is intended for the publication of original papers on optics (especially the

(*Continued on page 196*)

THE VERSATILITY OF X-RAYS

By GEORGE L. CLARK

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IN all the history of science there is no more brilliant page covering a period of less than thirty years than that which is concerned with X-rays. From the status of a misunderstood and somewhat dangerous plaything, they are only now becoming a useful tool of astonishing versatility and of untold possibilities in the fields of biology, pathology, medical diagnosis, physics, chemistry and numerous phases of business and industry. Even yet the roentgenologist, for example, may little realize, in the process of application of X-rays to diagnosis of human ills and to the obliteration or alleviation of suffering, that this same energy is being applied by the botanist, the physicist in his searchings of atomic anatomies, the chemist, the metallurgist, the great industrial corporation, or even the ordinary mechanic, to the solution of almost innumerable problems. Those transverse electromagnetic vibrations, or bullet-like quanta of energy, which we call X- or Roentgen rays and which we know to be in every way similar to ordinary light except that the frequencies are on the average about 6000 times as great as yellow light, are meeting the manifold demand; in fact, they are so helpful in many instances that there is an increasing tendency to expect them to solve any experimental or theoretical impasse after all other tools of science have failed. Hence a brief survey of the matchless versatility of X-rays must also serve as a delimiting process.

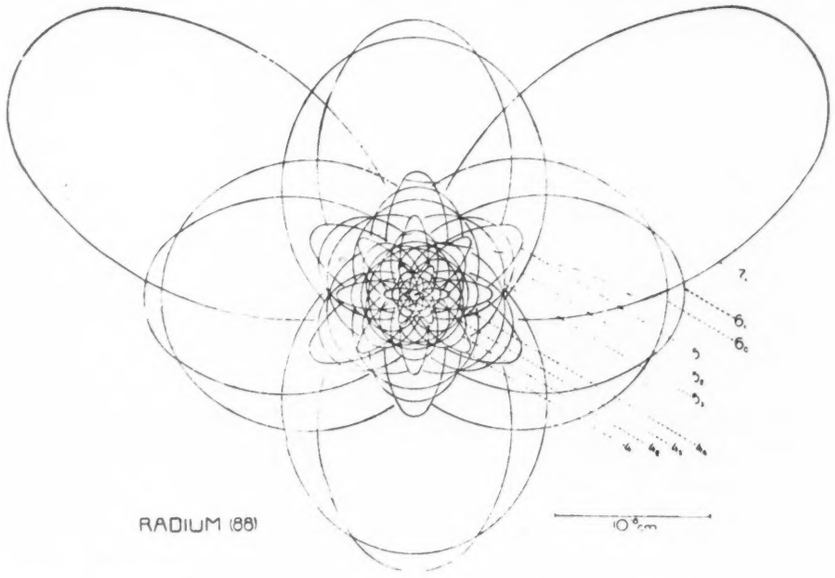
The applications of X-rays may be roughly divided into, first, those depending upon direct utilization of the radiation; second, the determination of crystal structures; and third, the founding or testing of theories of the structure of the atom. This seems to be a better system of classification than any attempt to apportion the applications among the various sciences, simply because it is impossible in these days to define the boundary lines between sciences. These three classes will be considered systematically and briefly. It is obvious that a monograph instead of a paragraph might easily be written on each one of the thirty-seven general fields of application.

I. Direct Applications

1. Roentgen Therapy. The well-known treatment of tumors by X-rays, of course, depends upon the preferential destructive action of the radiation upon cells with abnormal growth function. It is an occasion for great rejoicing that roentgenologists after years of empirical measurements and estimations of dosage and protection are applying the experimental results of physicists upon the fundamental laws of X-ray production to quantitative treatment in terms of wavelengths and intensities measured by accurately calibrated ionization chambers. Here is a pertinent example of the age-old truth that any good thing may be very harmful if ignorantly used. The newer results in the actual curing of cancerous conditions when not hopelessly acute, and even in the temporary relieving of suffering in far progressed cases stamp these rays, intelligently used, as literally a great beam of light searching the dark places in medical science. The qualifying phrase, intelligently used, should effectually answer attacks upon the use of X-rays as being deadly dangerous to man because experiments with mice result in death, sterility or abnormal young. That phrase indicates scientific dosage and scientific protection based upon the quantitative laws of the absorption of X-rays by matter. It signifies and calls for many careful experiments upon the effects of X-rays upon all kinds of tissue, upon gland secretions and upon all physiological functions.

2. *Radiography-Medical Diagnosis.* This application is so well known as to require little comment. Many people have wondered how the medical and dental professions ever managed to get along without the X-ray photograph or the shadow on the fluorescent screen. The fact that X-rays penetrate matter and are differentially absorbed by regions differing in density enables the exact location of the tumor which is to be rayed, the diseased tissue, the incipiently tubercular lung, the broken bone and its proper setting, the pin caught in the child's throat, the decayed tooth and its proper filling. Thus do our amazed eyes see where before 1895 they could not. The use of auxiliary agents to define better the tissue or organ under observation, such as bismuth salts and gases, has developed into a science in itself.

3. *Radiography-Industrial Diagnosis.* Only within the past four or five years has it come to be realized that industrial products may be examined for internal defects by means of X-rays just as successfully as the human body. Consider how the safety of living in this age depends upon the strength and reliability of bridge and sky-scraper steel girders, steel rails, industrial plant equipment, especially for high temperature and pressure processes where faulty construction would result in conflagration, or all types of ordnance. Outwardly these may appear perfect, whereas inwardly there may be, as recently shown in tests at the Watertown Arsenal, offset cores, gas pockets, sand and slag inclusion, "pipes" (or cavities left when liquid metal shrinks in solidifying),



STRUCTURE OF THE RADIUM ATOM

spongy metal, cracks, etc. These imperfections may be readily detected radiographically through more than three inches. By means of X-rays not only may faulty castings be rejected, but an entirely new technique of controlled casting and successful substitution of castings for forgings gained. X-rays are being used now also to detect flaws in arc electrodes and similar products. Radiographic examination of coal for classification as to inclusions, slate, etc., is a promising possibility of the near future.

4. *Radiography—A New Tool for Mechanics, Detectives and Customs Officials.* The General Electric Company has just perfected a small portable X-ray apparatus with which plumbers may locate pipes hidden in walls or under floors, electricians may find wires exactly and almost instantaneously, and carpenters may know just where beams and nails are before proceeding to new constructional work. We are not surprised, then, that X-rays are becoming a valuable ally of the detective and the customs official in discovering concealed articles of value.

5. *Seed Germination.* Very little has been done so far in testing whether X-rays may have the same beneficial results as ultraviolet light upon the growth of organisms, seed germination, prevention of rickets, etc. Some experiments on hastening seed germination have given positive results.

6. *Stone Coloration.* X-rays produce coloration in glass, white topaz, amethyst, and other minerals which find application in jewelry. Temporary colors are produced also in crystals of rock salt, sylvite and other transparent substances.

7. *Fluorescence.* Many substances become luminescent or fluorescent in a beam of X-rays; in other words, these substances have the power of absorbing X-ray energy and re-emitting it as visible (or ultraviolet-light. Roentgen discovered X-radiation when his keenly watchful eyes beheld a barium platinocyanide screen brilliantly luminescent near a tube with which he was conducting cathode ray experiments.

There are many useful practical applications of this interesting property: for example, the immediate detection of the difference between a diamond and a glass substitute. Some substances, particularly sulfides and silicates, do not fluoresce unless a minute quantity of impurity is present; hence, here is a method for the indication of chemical purity. The alkali halides and other salts under X-rays produce fluorescent bands in the ultraviolet whose positions are sharply characteristic for each.

8. *The Activation of Catalysts.* One of the most promising fields for investigation is in the field of oxidation catalysis. A preliminary study in Germany within the past year has shown that a platinum catalyst is activated by X-rays so that the yields of sulfur trioxide from the oxidation of sulfur dioxide are increased by as much as 35 per cent at temperatures considerably below the optimum range. The activation was produced only in the presence of slight traces of moisture, so that evidently the X-rays caused an active layer of a peroxide on the catalyst. The whole question is being investigated for this process as well as the oxidation of ammonia, in the new laboratory in the Department of Chemical Engineering at the Massachusetts Institute of Technology, looking to increased yields, lower required temperatures and pressures, and less expensive catalysts.

9. *Chemical Reduction.* A few cases are known in which X-rays affect or cause chemical reactions. Iodic acid and potassium permanganate are both reduced by X-rays. This may be the explanation of the fact that absorption edges of some materials seem to have a fine structure, due to an element in more than one condition of valence. Organic compounds such as orthonitro-benzyl alcohol are completely decomposed by X-rays. This field offers great possibilities, particularly inasmuch as there are involved simple reactions, reactions in the presence of inactive metal colloids which, however, produce secondary rays, and reactions in the presence of colloids which are catalytically active and also produce secondary X-rays.

10. *The photoelectric conductivity* of solid dielectric changes markedly under X-rays and there is a considerable variation depending upon the allotropic form. Sulfur has been recently studied in this connection. Like ordinary light, X-rays greatly reduce the electrical resistance of selenium.

11. *The disruptive potential* of an explosive reaction is lowered by X-rays. The relationships are so definite that the phenomenon could be made a measure of the intensity and hardness of X-rays. Therefore, they should be a valuable agency in the whole study of the fundamental mechanism of explosions.

12. *Gaseous Ionization.* Inasmuch as monochromatic X-rays may be easily obtained and the intensity controlled, they are far superior to arcs or radium for ionizing gases. The photographed tracks of B-particles or electrons photoelectrically ejected by primary X-rays are of great theoretical significance. Furthermore, the effect of ionization in explosions and detonations may be easily and quantitatively studied. Wendt and Grimm recently found that so-called "antiknocks," such as tetraethyl lead, act by absorbing electrons on the explosion front. Ionization was produced in their experiments by an arc whose constancy of action is open to serious doubt. This mechanism may be studied with certainty by means of X-rays.

13. *Anodic polarization* is materially increased by X-rays with consequent possible applications in electrochemical processes, particularly the oxidation of organic compounds.

14. *Photochemical reactions* provide an excellent field for X-rays, again because wave-lengths and intensities may be so readily controlled. The oxidations of benzaldehyde, rubber and oil are accelerated to an enormous extent if X-rays are permitted to enter the reaction vessel. The radiation hypothesis may be subjected to searching test in such experiments which may be followed quantitatively.

15. *Corrosion of metals* seems to be profoundly affected by X-rays as also by ultraviolet light. It may prove possible to passivify surfaces and to study the mechanism of corrosive action by this new method.

II. X-Rays and Crystal Structures

16. *Elements.* Only about ten years ago Laue predicted that crystals, because of the regular marshalling of atoms in parallel planes within them, should act as a diffraction grating for X-rays in the same way as finely ruled lines on glass diffract light. Today the actual crystalline structures of forty-three of the chemical elements, practically half of those which have been discovered, are known with a considerable degree of exactness. We are coming to know more about the solid state of matter than any other; we have more information bearing upon the actual existence of atoms and of the forces between them than was ever vouchsafed through the intermediation of any other experimental tool. It is now possible to correlate and explain the physical and chemical properties of these fundamental building blocks of matter from a knowledge of atomic arrangement and dimensions. The several ingenious experimental methods by which X-rays are used to discover inner architecture have caused to be written in large letters upon history's page the names of Laue, the Braggs, Hull, Debye, Duane, Siegbahn, Seeman and others. Difficulties of experiment and interpretation are enormous, but with the aid of the mathematical theory of space groups and improved technique the puzzle of the remaining elements will be solved. Just now the structure of *solid argon*, one of the rare inert gases

of the atmosphere, has been announced as composed of face-centered cubes with an edge length of 5.43×10^{-8} cm. An idea of the magnitude of this experimental achievement is given by the fact that these crystals were formed at about –200° Centigrade.

17. *Allotropy.* The X-ray crystal method explains and detects the different forms in which the same element can exist; carbon, cobalt, sulfur, tin and iron atoms, for example, may arrange themselves in more than a single kind of space lattice. Anomalous behavior of metals, appearing as sudden discontinuities in the variation of physical properties with temperature and pressures, is usually due to polymorphic transitions immediately detected by X-rays. On the other hand, recent work with tungsten single crystals showed sharp discontinuities in tensile strength as temperature was raised, but absolutely no change in crystalline structure. Again the results of X-ray analysis tell us at once why graphite with perfect slip-planes, weak crystalline forces and large distances between planes, is so good a lubricant while a diamond, also carbon, is so hard and actually an abrasive.

18. *Inorganic Salts.* The crystalline structures of more than 150 inorganic compounds are now established. These range in complexity from lithium hydride or rock salt to uranyl nitrate hexahydrate, hexammine nickel chloride, or ammonium fluomolybdate—and just now ammonium heptafluoirconate and heptafluohafniate. The importance of this information in every phase of science and industry cannot be over-estimated.

19. *Organic Compounds.* The Braggs in England have been pioneers in the study of the constitution of organic compound crystals in which whole molecules are singly acting units in the space lattice instead of atoms. Now we know with exactness the actual length of long soap molecules (stearic acid is 39.6×10^{-8} cm.). The polarizing property of tartaric acid and its racemic forms are natural consequences of the arrangement of molecules in crystals. The fascination in these results lies in the fact that perfectly definite visualization of heretofore immeasurably small units, of valence, and of stereoisomerism is possible.

20. *Metals.* One of the most fruitful fields for X-ray investigation of structures is that of the metals. As we ordinarily know metals, they are constituted of very small crystalline aggregates in random orientation. Working, rolling or drawing produce more perfect orientation and effects which may be exactly followed, thereby removing metallurgy from empiricism. Germany has taken the lead in founding an institute solely for the purpose of metallographic investigation by means of X-rays. The X-ray method has resulted also in the production of single metal crystals of great size which have altogether different properties from the crystal aggregate metal. Professor Bridgman of Harvard now finds it possible to construct a galvanic cell from zinc alone, one pole being a single crystal, the other the aggregate.

21. *Alloys and Solid Solutions.* In the past two years more progress has been made in understanding the true constitution and structural changes in steels, brasses, bronzes and other common alloys, than in all the long history of these invaluable materials. Unerringly the X-rays have defined the allotropic modifications of iron, and the changes from one to another, the appearance of new compounds of definite composition, the limitations of solid solution within which lattice dimensions change linearly with percentage composition of the components, the ranges of instability, the necessary composition for a desired property of hardness, ductility, etc., the effect of working or annealing, the alternative substitution of one atom for another or the interstitial entrance of one kind of atom into the lattice of another, and the shapes of atoms, some acting as spheres and others, such as zinc, definitely elongated in one direction. The possibilities are limitless, the results invaluable theoretically and technically. Solid solutions and mixed crystals of the alkali and ammonium halides so studied have given important information upon the limitations of the mutual solubility of melts and upon lattice and atomic dimensions not otherwise possible to obtain.

22. *Technical Materials.* There are so few solids which are really amorphous under the searching scrutiny of X-rays that X-ray analysis may be successfully used on a wide variety of technical materials: coal, leather, soap, starch, sugars, paper, textiles, rubber, paints, ceramics. Cellulose fibers have a crystalline structure which is maintained, though the lattice dimensions change, even when swelling in liquids has occurred. This swelling might easily be made the measure of the acidity of the solution or of the tensile strength of fabrics. Pure rubber has been recently obtained as crystals with apparently one molecule of C_5H_8 per unit cell. The nature of rubber fillers, the chemical or physical state of sulfur in vulcanization, or the general validity of the polymerization theories may all be ascertained. Glass and fused quartz may be tested for incipient devitrification, for even the slightest crystalline structure is revealed by X-ray diffraction on the photographic plate. The advantage of this information in the production of fine lenses and mirrors is obvious. Structural changes in ceramics will at last be linked with definite chemical change. The differences between white lead paint prepared in different ways will be interpreted from the standpoint of the chemical identity of definite basic carbonates.

23. *Films.* We do not know just how thick a layer of definitely arranged atoms or molecules must be in order to produce detectable crystal diffraction patterns. Sir William Bragg has found that gold leaf, so thin that it becomes perfectly transparent upon heating, gives good effects. This bodes well for a successful attack upon absorption films, oriented surfaces in liquids, electrodeposited metal films, corroded surfaces and the structures of the surfaces of catalysts. This promising field is being subjected to intensive study under the writer's direction at the Massachusetts Institute of Technology.

24. *A New Method of Chemical Analysis.* Since even minute quantities of crystalline substances may be detected by X-ray diffraction patterns characteristic for each, it is obvious that unknown pure substances or mixtures may be chemically analyzed, particularly if standards for the pure materials are available. Relative quantities may be judged from intensities. The method is limited inasmuch as true solid solutions do not, in all cases so far studied, yield new and characteristic lines, but act as single entities. Valuable application is to be found in the distinction between true chemical compounds, solid solutions, mixtures or adsorption complexes; for example, purple of Cassius has a diffraction pattern to which both stannic hydroxide and gold contribute separately. Hence this beautifully colored substance is not a chemical compound but an adsorption complex. Mixtures of the rare earths are easily tested and identified. The long controversy as to the fundamental difference between the red and the yellow forms of lead oxide has been recently settled; the color does not depend upon different states of subdivision but upon clearly different crystal structures. On the other hand, the apparently greatly different hydrated tin oxides give precisely the same X-ray diffraction patterns. Differential absorption of X-rays by matter, particularly by sheets of metal and alloy, might be employed for rapid analysis after known values for standard samples are established.

25. *Control of Precipitation.* One of the great problems in analytical chemistry is to obtain precipitates which may be easily handled. Many compounds readily precipitate in colloidal form and cannot be filtered. Under other conditions of temperature and concentration distinct crystals may form. The dividing line between colloid and crystalloid is immediately established by the X-ray powder diffraction method; the first produces no diffraction lines, but the second does, even in incipient formation. Similarly the processes of ageing and coagulation of colloids may be followed step by step.

26. *Dimensions of Atoms and the Periodic Table.* Numerous attempts are being made to derive, from the accurate data on the dimensions of crystalline unit cells, the constant size of atoms, and to establish the periodicity of size and of crystalline type. Certain basic assumptions are necessarily involved as, for example, that the potassium and chlorine atoms in potassium chloride have the same size because they have the same number of electrons. The data so obtained are interesting and valuable, but by careful analysis the fact is established that the hypothesis of constant atomic radii is not rigorously true. The size of the lighter atoms particularly seems to depend upon the nature of the compound in which they are combined.

27. *Refractive Index.* W. L. Bragg, in some very new work, has undertaken with success, the difficult task of relating crystal structure to such properties as refractive index, so that one may be inferred from the other. Extension to crystals other than calcite will be awaited with interest.

28. *Secondary Valence.* Many years ago Werner, in one of the classic works on chemistry, set about to explain the structure of such secondary valence compounds as $Ni(NH_3)_6Cl_2$, hexammine nickel chloride, in which six electrically neutral molecules of ammonia are bound by residual forces by a neutral molecule of nickel chloride. He maintained that the six ammonia molecules should be distributed at the corners of an octahedron around the central metal atom. X-ray analysis proves directly that this is actually the case, as it is also in $Zn(BrO_3)_2 \cdot 6H_2O$, K_2PtCl_6 and other compounds. The present writer has determined the structures of some of the alkali polyhalides, such as potassium or cesium triiodide, and found again that the identity of the complex acid ion indicated in solution is maintained as a single acting unit in the solid space lattice. The actual forces which enable these complex compounds to form, the sharing of electrons, singly or in pairs, may be adequately related to the very definite crystal structure information upon the basis of the Bohr theory, which will be considered a little later.

III. X-Rays and Atomic Structure.

29. *The Importance of Atomic Number.* Not only do X-rays have objective application directly and in the detection of crystalline structure, but they have subjective application to the inner architecture of those atoms which are producing the radiation itself. Every element used as a target against which is impinging a stream of cathode rays accelerated by a high voltage, produces as a consequence X-rays with wave-lengths which are characteristic of that element. When the spectrum is spread out by means of a crystal with a known grating or lattice constant, characteristic groups of emission lines appear. Moseley, in 1914, discovered that if the square root of the frequencies of these rays were plotted against the atomic numbers of the elements, straight lines result, and that this relationship is not true if atomic weights instead of numbers are substituted. This was splendid evidence of the essential continuity of structure in proceeding from hydrogen, number 1, to uranium, number 92, and of the fundamental importance of the atomic number synonymous with the number of nonnuclear electrons. The great value of X-ray spectra lies in the simplicity of the series as contrasted with optical spectra. The K series, for example, has only four lines for every element.

30. *Stokes Law.* X-rays verified completely the law that fluorescent characteristic radiation can be excited only by primary rays of the same or shorter wave-lengths. We know, however, that the four K lines always appear together and must be excited by energy somewhat greater than that corresponding to the "hardest" of the four.

31. *Atomic Models—The Bohr Theory.* The science of X-rays has had, since 1913, the great aid of the Bohr theory of atomic structure, which was presented to the world in the attempt to correlate the seemingly hopeless impasse between the empirical optical spectroscopy of Balmer, Ritz and Rydberg, the quantum theory of Planck, and the classical electrodynamics of Maxwell and Lorentz. Bohr conceived of the atom as a positively charged nucleus around which were rotating in orbits a number of electrons corresponding to the atomic number. These orbits represented definite energy levels or steady and non-radiating states, while radiation was emitted only during the transition of an electron from one orbit to another of lower energy, or absorbed in the transition to a higher energy level. While this theory successfully predicted and adequately explained the results of X-ray spectroscopy, at the same time experimental X-ray spectroscopy has been one of the powerful supports of the theory, assisting in its development and strengthening its postulates until now the Bohr theory is generally accepted by the physicist and chemist alike to explain both the facts of spectroscopy and of chemical valence. Radioactivity and the epochal experiments of Rutherford in bombarding hydrogen out of atoms of all the elements from boron to potassium, except carbon and oxygen, give us experimental insight into the nuclei of atoms. Chemical reactions and optical spectroscopy give us information as to the outermost constitution of atoms. Upon X-rays must rest very largely the responsibility for our knowledge of the inner electrons, those in the innermost K ring, the second L ring with its three energy levels, the third M ring with its five levels, and so on out. In Figure I is shown the Bohr conception of the radium atom. Upon this scale the nucleus is too small to be shown even by a dot. The circles and ellipses represent the electron orbits, 88 in all.

32. *The Combination Principle.* One of the great strengths of the conception of the production of characteristic X-rays by interorbital transitions is the truth of the combination principle. If the K-Beta line is produced by a transition from the M to the K ring, then its frequency should, upon this principle, be equal to the sum of the frequencies of the K-Alpha line (from L to K) and the L-Alpha line (from M to L). The principle is rigorously checked by the experimental values.

33. *The Discovery and Identification of New Elements.* The simplicity of X-ray spectra and of the relationship between frequencies and atomic numbers has predicted and triumphantly identified hafnium, element number 72. The minutest traces of the still unknown 43, 61, 75, 85 and 87 in minerals should disclose themselves as characteristic emission lines or absorption discontinuities. All have been sought, but so far without success. It may be confidently predicted that if these elements do exist in matter to which man has access, they will be discovered by the X-ray method. Only by this method has it been possible finally to straighten out the great enigma of the rare earths; for in passing from one to the next of these closely related elements electrons are added, not in outer shells, but to inner incom-

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SOME PROBLEMS IN OIL ENGINE DEVELOPMENT

By O. P. ROBINSON

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ALTHOUGH "oil engine" may be taken in general to mean practically every type of internal combustion engine using liquid fuel, in this case it will be confined principally to the Diesel engine.

The Diesel engine is named after its inventor—Dr. Rudolph Diesel of Germany, who first conceived an engine working on this principle in 1893. He had been working with Professor Linde, the refrigerating engineer, and this experience brought to his attention the possibilities of an internal combustion engine which would give sufficient heat for ignition purposes by compressing pure air only.

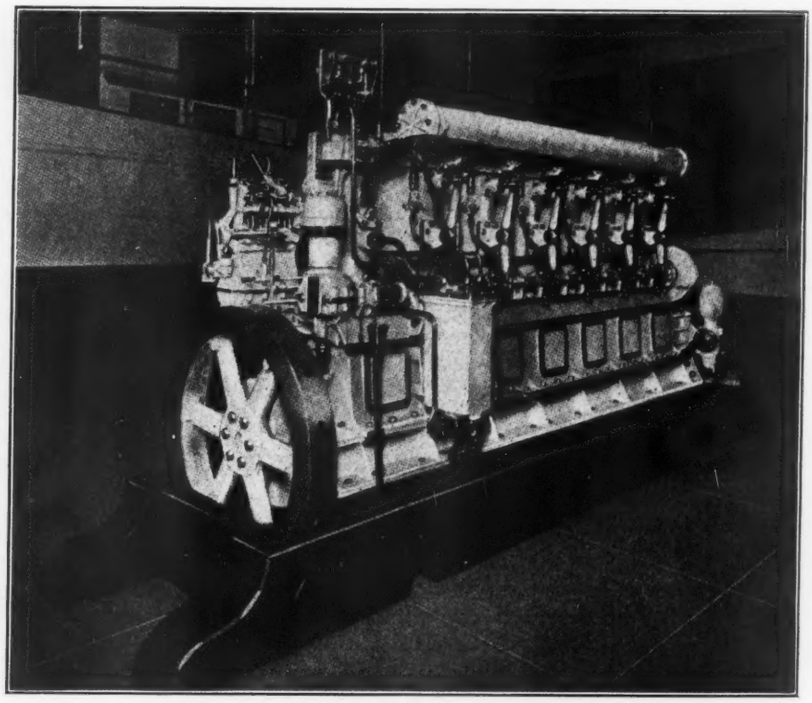
The Diesel engine then differs from the gas engine substantially as follows:

1. It depends entirely upon the heat obtained by the compression of pure air to ignite the combustible.
2. The combustible is in the liquid state, although finely atomized when it enters the cylinder.
3. Since the combustible ignites as soon as it enters the cylinder, the charge is admitted at the time when ignition should begin.
4. The combustible is crude oil which, compared with gasoline vapor, burns slowly and hence can be admitted to the cylinder over a comparatively long period and burned without an appreciable rise in maximum pressure.

The Diesel then utilizes the heat of compression to ignite the fuel. Experimentation and practice have proven that a compression pressure of from 425 to 475 lbs. per square inch gauge is necessary to insure ignition under all conditions. Although theoretically the maximum pressure should not exceed the compression pressure, it does slightly, so that with these pressures we have a maximum of about 500 lbs. per square inch. This first principle, then, defined the first problem, which was one of design; namely to construct a cylinder and head sufficiently strong to withstand these pressures. Of course, hand-in-hand with the pressures came high temperatures which further complicated the problem. The designer could not deliberately put enough metal in to make the parts amply strong, regardless of weight, for weight meant high cost, and even if that were not a serious objection, extra weight usually was not allowable, in marine work at least. Then again, in the case of the piston, connecting rod, and bearings, extra weight meant higher inertia forces than were allowable. So the designer tried to have the heavy sections only where they were necessary for strength, and by so doing ran into the necessity of joining heavy sections with light sections, which was a difficult task to accomplish successfully. If unsuccessful, the trouble started in the foundry. The thin sections cooled before the heavy sections, and in so doing pulled away, leaving a porous section which was void of strength and would hold neither gas nor water pressure. In case the foundryman foresaw this difficulty, he skillfully applied chills and sometimes obtained a good casting, but that did not solve the problem. When the engine was built and run, the chills were not there to equalize the temperature and control the expansion and contraction, and the heavy sections pulled the light, and cracks ensued.

These difficulties are overcome today by first using an iron mixture especially designed for the duty. Some manufacturers even are using cast steel for these parts because it allows much thinner sections for the same strength. Second, the design is combed over and over from the viewpoint of casting strains, and then from the viewpoint of operation strains. This latter has become a study in itself which today results in carefully controlling the cooling medium so that it has a high velocity at points where it is desirable to conduct the heat away rapidly and a lower velocity at points where the heat is not so intense.

The question of mechanically breaking up the fuel, and mixing it with the available oxygen was one that gave a great deal of trouble. The oil burned in these engines is the residue of crude oil after the more valuable parts, such as gasoline, kerosene and lubricating oil have been removed. It is naturally then a heavy and ofttimes gummy liquid. To obtain clean combustion, which, of course, was recognized very early as essential to fuel economy and the life of the engine, was the problem. It was soon learned that clean combustion meant having enough oxygen present to complete physical combustion, and that overall economy was dependent upon utilizing all the air that had been taken into the cylinder. Then the fuel pump was designed to deliver at a maximum just enough oil for the available oxygen, but how to distribute it evenly in the oxygen was another problem. This fuel, of course, had to enter the cylin-



A SMALL FOUR-CYCLE DIESEL ENGINE

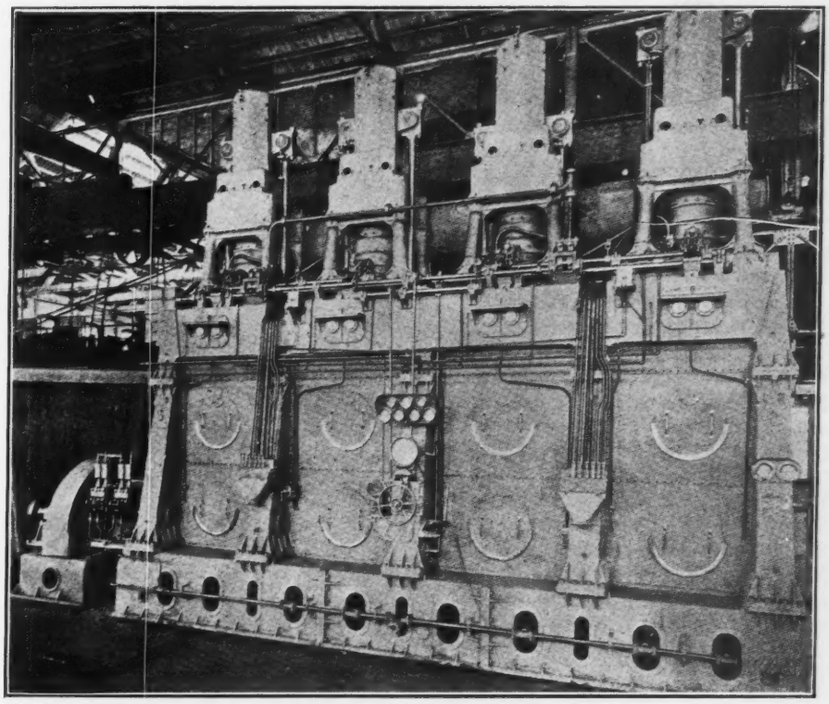
This engine represents a high development in the four-cycle type of Diesel engine. Two-cycle engines, which make possible a higher power-weight factor, are now being developed.

der against the compression pressure of about 450 lbs. per square inch. With these points in mind, many spray valves were and are being designed. Practically all of them have a nozzle which is placed to discharge into the combustion chamber, and most of the nozzles have a number of holes in them which direct the fuel oil into all parts of the combustion chamber. Back of the nozzle, however, there are many differences. These are dependent upon whether the designer feels that the fuel oil should have a rotary, straight, or combined motion when it reaches the nozzle. So we find the valve spindle, or the valve spindle guide, or both, have spiral or straight grooves to guide the oil, or they may have irregular baffles. There is another feature of the fuel oil injection system which is not settled today. It is, how shall the pressure be obtained to force the oil into the cylinder in a very short space of time, and also completely atomize it in the same period. Today this is done in two ways: One system is called air injection, and the other mechanical or solid injection. The former system is perhaps a little more in favor today and claims in general a little better combustion. With this system, each fuel valve is connected to the fuel pump and to an air supply as well. When the spray valve is opened, the air at from 800 to 1,000 lbs. per square inch gauge pressure blows the fuel oil in the form of a fine mist through the nozzle. Very good combustion is obtained by this method as pointed out by the fact that most manufacturers using it guarantee a fuel consumption of from .42 to .45 lbs. per B.H.P. hour with fuel oil of 18,000 B.T.U. per pound. The drawbacks to this system, if they may be called such, are as follows:

To supply air to the fuel valves requires a compressor that will absorb about 7 per cent of the engine power.

To make the unit self-contained, the compressor is built as a part of the engine, and this usually results in many compromises to keep the size and shape congruous with it. The result is scant valve areas, too few stages, and in some cases of high speed engines, too high speed for the good of the compressor valves. These points are all considered today, and the compressors are quite reliable, but then there is the necessity of designing all pipes and fittings to withstand the high air pressure, which is undesirable.

On the other hand, the mechanical or solid injection system simply admits the fuel oil under pressure and relies upon the nozzle to break it up. The more successful systems today use from 3,000 to 5,000 lbs. per square inch pressure in the fuel lines and very small holes in the nozzles. This of course means that the fuel pump must be built to withstand these pressures, and that a very efficient strainer must be used to keep any particles of solid matter from getting to the fine holes in the nozzles or under the valves. It is the writer's opinion that this system will soon predominate the field, but that to date, in general, the combustion is not as complete, for all cylinder sizes and speeds, as with the air injection system.



AN OPPOSED PISTON DIESEL ENGINE

This engine was installed in one of the Ford motorships. It develops 3,000 s.h.p. at a speed of 77 r.p.m.

Another subject which has commanded a great deal of attention from Diesel engine builders is that of torsional vibrations. This has not entirely to do with Diesel engines, but came to notice as steam turbines, internal combustion engines of all types, and reduction gearing began to be introduced in place of the old slow speed reciprocating steam engine. At first a fracture in the shafting of an installation, or a vibration at one speed and not at another were laid to a jinx, poor material, misalignment, etc., but as they became more frequent, investigations were made. This was only a few years back, and a thorough knowledge of the subject is not claimed by many today.

It may be well to first relate how this phenomenon, which has become known as torsional vibration, made its debut. Both marine and stationary installations were affected alike. In some cases a severe trembling of the entire system appeared at one speed but not at another. When this was the case the operator scratched his head and avoided that speed and unconsciously saved the installation. Even today the driver of an automobile notices that it is not as smooth at some speeds as at others. In other cases the system appeared to be running perfectly and a shaft, which had been calculated with exactly the same factor of safety as had many others, would twist off. Then again reduction gears wore out too rapidly. There were many firms in this country and Europe who, although they had many thousand horsepower of Diesel engines successfully operating, suddenly had to face the fact that their new designs were breaking crankshafts as fast as they were replaced. The shafts were designed in accordance with best practice, and were as strong as previous designs in every respect.

It would take many pages to relate the theories applied to this phenomenon and the various experiments carried out before one was found that held together. One of the stumbling blocks was that the steel in the first few fractures of this character was questionable, and that was taken as the solution. Another was the question of poor alignment of the shafting, and still another was that the high pressures obtained in the cylinders produced too severe shocks for the system. It may suffice then to merely state what has been learned and how the situation is handled today.

(*Continued on page 188*)

WATER POWER DEVELOPMENT IN THE UNITED STATES

By HAROLD K. BARROWS, '95

Associate Professor of Hydraulic Engineering, Massachusetts Institute of Technology

DURING 1924 the United States Geological Survey prepared a revised estimate of the water power of the United States. The results are shown in table A.

As will be seen from this table, the total developed water power in the United States is about nine million horse-power, and roundly speaking 60 per cent of this is east of the Mississippi River. The potential water power, which includes developed and undeveloped, on the basis of flow available 50 per cent of the time, is about fifty-five million horse-power, and of this over 70 per cent lies west of the Mississippi. In fact, nearly all of it is in and west of the Rocky Mountains, and the Pacific States—California, Oregon and Washington—alone have nearly 40 per cent of our potential water power resources. Fundamentally, as a district the Pacific States also now lead in the amount of developed power, with about 23 per cent of the total.

Considering individual states, those leading in water power are shown in table B.

As will be noted, New York leads in developed power, due to the great developments at Niagara Falls, although closely followed by California. Due to the potential power at Niagara Falls and on the St. Lawrence River, New York State also holds an important position in respect to potential power.

The total potential power in the United States of fifty-five million horse-power does not represent the ultimate installed capacity of wheels, which capacity is normally considerably in excess of the 50 per cent flow basis. It is safe to say that the ultimate wheel installation will reach seventy to seventy-five million horse-power, so that the present development represents about one-eighth of the available potential water power of the country.

The estimated capacity of stationary prime movers in the United States, including steam, water and other forms of power, now totals about fifty million horse-power. A little less than one-fifth, therefore, of the total power used at the present time is water power.

During the past two or three years the construction of new water power plants has proceeded rapidly. A list of hydro-electric plants completed or under construction in 1923-25, as pub-

TABLE A

Water Power of United States by Districts

	DEVELOPED		POTENTIAL Available 50 Per Cent of Time	
	Horse-power	Per Cent	Horse-power	Per Cent
New England	1,387,400	15.2	1,978,000	3.6
Middle Atlantic	1,731,900	19.1	5,688,000	10.4
East North Central	829,800	9.1	1,391,000	2.5
Southern Atlantic	1,296,000	14.3	4,464,000	8.1
East South Central	345,600	3.8	2,004,000	3.6
Total east Mississippi River	5,590,700	61.5	15,525,000	28.2
West North Central	459,700	5.0	1,844,000	3.4
West South Central	16,700	0.2	888,000	1.6
Mountain	880,800	9.8	15,513,000	28.2
Pacific	2,139,000	23.5	21,260,000	38.6
Total west Mississippi River	3,496,200	38.5	39,505,000	71.8
GRAND TOTAL	9,086,900	100.0	55,030,000	100.0

TABLE B

Leading States in Water Power

	DEVELOPED		POTENTIAL (Available 50 Per Cent of Time)	
Rank	State	Horse-power	State	Horse-power
1	New York	1,543,000	Washington	7,871,000
2	California	1,451,800	Oregon	6,715,000
3	Washington	480,400	California	6,774,000
4	Maine	473,200	New York	4,960,000
5	North Carolina	431,500	Idaho	4,032,000

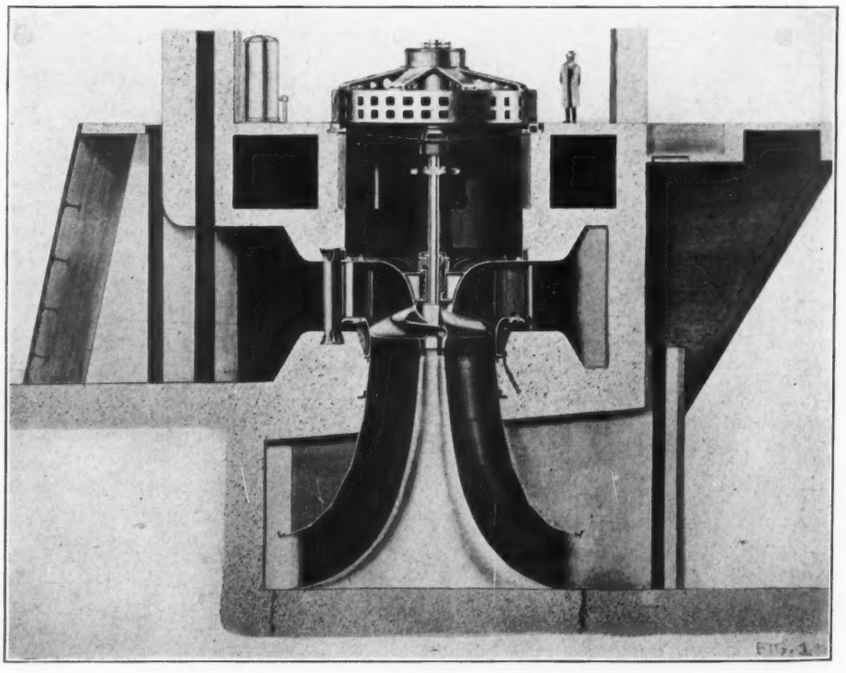


Fig. 1

NEW PROPELLER TYPE WHEEL SETTING

This is an axial flow wheel of specific speed much higher than that of usual reaction wheel practice.

lished by the *Engineering News-Record* on January 3, 1924, has been used in compiling the following table:

Hydro-Electric Plants under construction in United States 1923-25

District	Capacity Horse-power	Per Cent of Total
New England	82,600	3.2
N. Y. and Mid. Atl.	477,100	18.4
South	864,500	33.3
Pacific and Mt.	787,000	30.3
Remaining U. S.	383,400	14.8
Total	2,594,600	100.0

This table indicates the relatively rapid progress of water power development now under way, averaging 700,000 to 800,000 H.P. yearly of new plants for these three years. As a district the South leads, although closely followed by the Pacific and Mountain district. The installations vary in size from the 210,000 H.P. plant of the Niagara Falls Power Co. (three 70,000 H.P. units), down to plants of a few thousand horse-power. The highest head, of 2,495 feet, is at the Balch No. 1 plant of the San Joaquin Light and Power Company, in Southern California,—an impulse wheel development, to be completed in 1926. The Oak Grove plant of the Portland, Ore., Railway and Light Company, with a 960-foot head, completed in 1924, leads in respect to the head thus far used for reaction wheels.

The average head developed at these new plants varies greatly in the different sections of the country. It is from about 200 to 250 feet in New England and the Middle Atlantic States, about 75 feet in the South and 630 feet in the Pacific and Mountain district, — averaging for the whole country about 325 feet.

Two factors have been of importance in respect to the development of water power in the past few years, (1) the establishment of the Federal Power Commission, (2) the so-called super-power movement.

The *Federal Power Act*, passed in 1920, has made possible the use and development of water power in the various public lands, including National Forests and Indian Reservations, etc. Prior to 1920 development of water power on the public lands had proceeded very slowly, owing to the various complications required in getting rights from the government for such developments.

The Federal Power Commission, which briefly is "to provide for the improvement of navigation, the development of water power and the use of the lands of the United States in relation thereto," consists of the secretaries of war, interior and agriculture, and the work of the Commission is performed by and through the personnel of these three departments. The Commission, in co-operation with the other executive departments and with state agencies, is empowered to investigate the cost of water-power development, its availability for market and its fair value in any region to be developed.

Licenses are to be issued to citizens, corporations, municipalities or states, to construct, operate and maintain projects for the development and improvement of navigation and for the development, transmission and utilization of power,—(1) from or in any of the navigable waters of the United States; (2) upon any part of the public lands or reservations, and (3) to utilize the surplus water or power from any government dam.

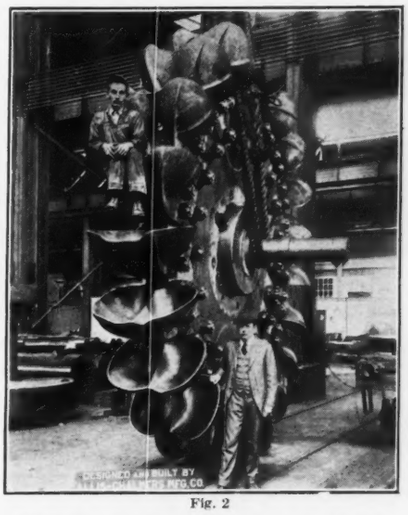


Fig. 2

BUCKET WHEEL FOR 30,000 H.P. UNITS

The weight of the assembled wheel is 25 tons.

Licenses under the act are to be issued for a period not exceeding 50 years, with an annual charge reasonable in amount, to be fixed by the Commission, to cover cost of administration of the act and as recompense for use of national lands or other property.

As noted in the Third Annual Report of the Commission, dated June 30, 1923, in three years since the passage of the act applications involving an estimated installation of over 21 million horse-power were received, permits and licenses issued for an aggregate installation of over 7 million horse-power, and about 2.5 million horse-power built or under construction under licenses of the Commission. Of this latter item about 70 per cent is water-power in or affected by the public or forest lands, etc. Of the remaining 30 per cent, which is in navigable waters, practically all is at Niagara Falls. It will be seen, therefore, that the important field of action for the Federal Power Commission is that of the public and forest lands, especially in the West.

The extent to which the Commission has authority over rivers outside of the public and forest lands, etc., is not clearly defined by the Federal Water Power Act. Theoretically, under the act its jurisdiction would include all navigable streams, and carrying this to the limit, even small tributaries to navigable streams.

The Commission has handled this phase of the matter by making a ruling, when requested in various specific cases, usually that there is no effect on navigation. There is, however, some uncertainty as to the necessity for applications in such cases and as to possible change in basis for rulings by future commissions, and it appears desirable to definitely limit *in the act itself* jurisdiction to the portion of rivers commercially navigable *in fact*. The jurisdiction of the Commission was particularly intended to cover water-power development in the various public lands and at government dams on navigable streams and if extended further, especially in an indefinite manner, is likely to be a hindrance rather than a help in encouraging the investment of capital in power projects.

The *super-power zone*, as reported upon in 1921 by the United States Geological Survey, includes the greater portion of the New England States and Atlantic States, within which zone is concentrated about one-fourth the population of the United States—including 315 electrical utilities, 18 railroads and 96,000 industrial plants. The annual power requirement of this zone in 1930 is estimated at about thirty-one billion k.w.hrs.—of which about one-fifth can be supplied from water-power. The system recommended comprehends large steam plants at tidewater and on inland waters, as well as the utilization of available hydro-electric power. The power so generated is to be co-ordinated through a system of interconnected transmission lines of high voltage,—in fact, much of the economy incident to super-power will be the result of system interconnection. The annual coal saving, including that from railroad electrification, was estimated at about fifty million tons.

Another report on super-power by the "Northeastern Super-power Committee," under the leadership of Secretary Hoover, in 1924, further emphasizes the desirability of this movement. The study of this committee indicates, however, that power generated in large steam plants at the

(*Continued on page 190*)

RECENT BOOKS

Chemistry in the Nineteenth Century. An Account of the Achievement and the Present State of Knowledge in Chemical Science. Prepared under the guidance of a Committee representing the Scientific Societies with Dr. E. F. Armstrong, F.R.S., as chairman and editor. New York, The Macmillan Company, 1924.

This book contains a series of 25 monographs upon important phases, both of pure chemistry and the technical applications of chemistry. It purports to present the position of chemical science in Great Britain, as illustrated by the exhibits in the Chemical Hall at the British Empire Exhibition (1924). Actually, science is not limited by political boundaries, and the achievements of science set forth in this book embrace the whole world of progress, although they justly show the pre-eminent part played by British men.

Every one of the monographs is written by an expert in the particular field. The reader cannot be an expert in all of the fields, but he must have a thorough appreciation of the fundamental principles of chemistry and physics. To such a reader the experts in turn tell in fairly simple language and without too specialized detail the great accomplishments in each of the particular departments. These accomplishments are not necessarily limited to recent years. Rather it is shown how the present achievements have developed from fundamental discoveries whether the latter were made recently or long ago.

This would be an admirable book for a candidate for the doctor's degree in chemistry to read as a part of his general preparation. The book is altogether inspiring and readable to one who seeks serious reading and has sufficient understanding. It is not to be recommended for superficial reading, nor for an underclassman.

ARTHUR A. BLANCHARD, '98.

Power Plant Machinery, Vol. II, by W. H. James, Associate Professor and M. W. Dole, Department of Mechanical Engineering, Mass. Inst. Tech. John Wiley & Son, New York, 1924. pp. 267.

This volume is primarily descriptive of the mechanical details of typical power plant equipment. It is divided into two parts; the first deals with reciprocating steam engines, steam turbines, air compressors, pumps and a few examples of smaller steam, hydraulic and pneumatic machines. The second considers the machinery for heating and purifying boiler feed water, also condensers, and the equipment auxiliary to them and some miscellaneous machinery and apparatus of general interest. The machinery described is sufficiently representative in its class so that the reader should be able to readily understand similar machines of different detail design. The illustrations are numerous and so clear that the essential things are made obvious with a brief amount of text. Furthermore it is not made tedious with the description of minor details which would be of little interest except to those actually designing this type of machinery. The book is not merely descriptive but is made more instructive by stating, where necessary, the principal reasons for, or advantages of, the particular design selected.

J. J. EAMES, '02.

This department is conducted by the members of the Institute Library staff. All books referred to may be found in the Institute Library. As the space is limited, only a brief outline can be given, but it is hoped that this page will prove helpful to those interested in the acquisition of a reference library.— EDITOR.

The Modern Soap and Detergent Industry. Including Glycerol Manufacture. By Geoffrey Martin. In 3 volumes, Vol. 1: Theory and Practice of Soap Making. London: Crosby, Lockwood & Son, 1924.

The soap industry has undergone rapid change and development within the last few decades, both as to raw materials and on the engineering side, largely as a result of scientific research. The author has aimed to cover exhaustively all recent progress in all branches of the industry, both in England and America, and has cited German, Dutch and Russian practice where it varies therefrom. This first volume takes up the nature of soap and detergent action, raw materials, perfumes, fatty acids, layout of factories, boiling process, household and laundry soaps. Full methods of analysis are given. Vol. 2 will include recipes, processes, and patents, and Vol. 3 glycerol manufacture.

The Properties and Uses of Wood. By Arthur Koehler. New York: McGraw-Hill Co., 1924, 354 pp.

An attempt to supply, mainly in non-technical language, more definite information regarding timber than can ordinarily be obtained in the trade. Data has been secured largely from researches of the Forest Products Laboratory maintained jointly by the U. S. Forest Service and the University of Wisconsin. There are chapters on physical, mechanical, and chemical properties of wood, on kiln drying, wood preservation, measurement of timber products, etc., and there are over forty useful tables and numerous illustrations and graphs.

Structural Engineering: Strength of Materials. By George F. Swain, Gordon McKay Professor of Civil Engineering in Harvard University. New York: McGraw-Hill Co., 1924. 569 pp.

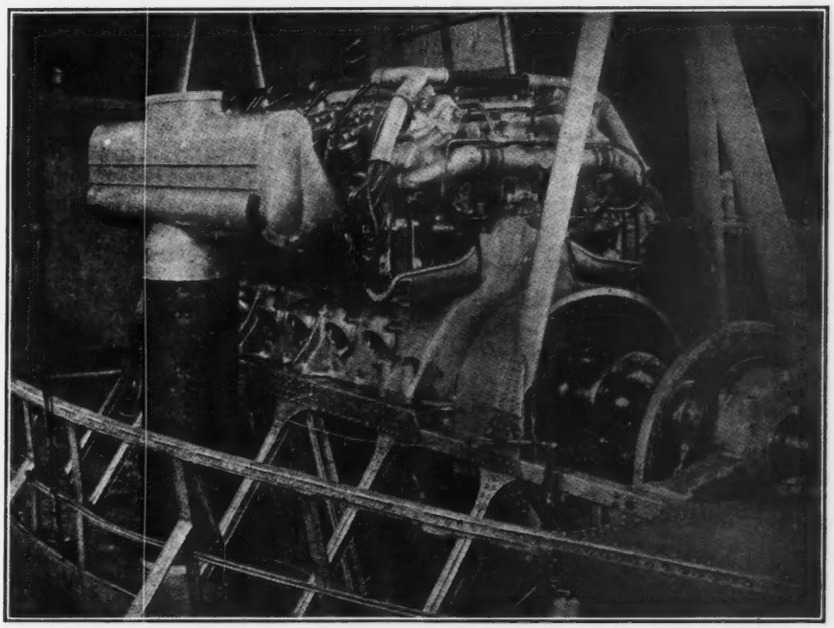
Preface states: "The present volume is the first of a series treating of the theory and designs of structures, embodying the course which the writer has been giving for many years, with amplifications which, it is hoped, will make it a fairly complete treatise for engineers." In other words, it is intended to carry the student beyond the limits of most engineering courses and, by reference to other works, aid him to pursue the subject to the full extent of present knowledge.

The three remaining volumes of the series will cover: (2) properties of materials, (3) theory and design of simple structures, and (4) complicated and statically indeterminate structures.

(*Continued on page 194*)

MONTHLY NEWS

ZR-3 Motors. The cut illustrates the installation of one of the five motors of the Los Angeles (ZR-3) in its nacelle. These Maybach engines, specially designed for this service, incorporate the results of experience gained during the war when Maybach engines achieved quite a reputation. Each of these engines has twelve cylinders arranged in V-form. Each cylinder has one inlet valve, two exhaust valves and two spark plugs. There are four Maybach carburetors carried between the two rows of cylinders. Direct reversing, doing away with the use of reversing gear and clutches, is obtained by means of a sliding camshaft, and the ignition which is by means of Boch magnetos, works in either direction of rotation. The engines are started by compressed air, and it is claimed that a large starting movement is secured on a very small consumption of air. Each engine develops 400 b.h.p. at 1,400 r.p.m., giving a total of 2,000 h.p. for the ship and driving it at 75.8 miles per hour.—*Scientific American and Aviation.*



ONE OF THE MAYBACH ENGINES INSTALLED IN THE LOS ANGELES

These engines are five in number and have twelve cylinders each. They are directly reversed by means of a sliding camshaft.

The Liberty Motor Inverted. Because the automobile requires road clearance and at the same time requires the lowest position for the driving shaft so as to drive straight back to the axle, automobile engines have developed so that their cylinders and their parts are largely on top of the crank shaft. Inevitably influenced by automotive practice, most airplane engines have been developed with a similar arrangement of parts.

But an airplane must swing a big propeller about ten feet in diameter. This necessitates a crank shaft placed way up in the air, and using the usual type of motor. The space, which is easily available and more convenient below the crank shaft, is sheer waste.

Recently it was decided to turn the Liberty Motor upside down and have the cylinders below the crank shaft, where they belong on an airplane, thus giving immediately the maximum of propeller clearance, adding greatly to the visibility and permitting much more compact and sensible designs of plane. This has been accomplished with gratifying success. —*Aviation.*

Magnetic Recovery of Combustible in Boiler Plant Refuse. In actual operating practice, the amount of combustible in boiler plant refuse may range from a few per cent to as high as forty or fifty per cent. In Europe magnetic separators have been used with considerable success, one firm reporting 87 per cent recovery. The principle in use is that when coal is subjected to heat, the ash-forming constituents tend to fuse together into clinkers quite separate from the unburned coal and coke. These clinkers contain all the iron present in the ash, so are slightly magnetic. By passing the boiler refuse, crushed to such a size that the mechanical bond between clinker and combustible is broken, over a magnetic field, the clinker is retained by the magnet while the combustible passes on.

Hydraulic Transmission. A double-end Unit car using a gasoline engine and a hydraulic transmission, with a seating capacity of 60, has been in operation in the N. Y., N. H., and Hartford R.R. since the fall of 1923. This form of drive is a promising development and if proved successful, will broaden the field of application of the gasoline engine in the traction field.—*Electric Traction.*

Modern Alchemy. Professor Meithe's claim to have accidentally discovered a method of changing quicksilver to pure gold received a rather sceptical editorial notice in the *Scientific American* for November.

Soon afterward, Mr. E. E. Free, editor of the *Scientific American*, announced that that magazine is directing a series of experiments to try to produce the same results but by a different method under Prof. H. H Sheldon, Department of Physics, New York University, using apparatus enclosed in a quartz lamp. Meanwhile a duplicate of Prof. Miethe's apparatus is being sent to this country for study.

The theory is that a current of 170 volts and proper amperage will "crack" the atoms of the quicksilver, knock off the 80th planetary electron and thus leave atoms with a planetary system of 79 electrons—pure gold.

EDITORIALS

ET TU BRUTE!

Paternalism has been one of the evils to which students at Technology were not subjected. Regulation of the personal affairs of the students was confined mainly to advice and in some cases, expulsion for those who flagrantly offended common decency or morality. The maxim was that there were "no rules until you broke them" and a very broad-minded and considerate judge has passed upon any transgressions. This attitude on the part of the Institute may seem a little cold and impersonal but it has proved a very satisfactory and workable one. It amounts to the faculty allowing the student to do as he pleases, within certain broad limits, as long as he continues to keep up in his studies.

The late blast from those who solemnly convened at the public library to join in "damning" the students, has fortunately failed to startle greatly the Institute authorities. It was a very ill-advised sortie, quite comparable to Don Quixote's famous encounter. The object of the attack is undoubtedly there but not in the gigantic proportions which the report indicated. The percentage of students at Technology who indulge in drinking, gambling and immorality is certainly no greater than at any other college of equal size. It is undoubtedly far less than the percentage of the good citizens of Boston, so aghast at these disclosures, who indulge in the same vices. We are hardened to vilification by the Boston papers, but when representatives of student organizations and members of faculties join in the merry pastime, we can only faintly murmur Caesar's dying words.

LAW AND THE ENGINEER

Little is mentioned in the technical press of the necessity for a knowledge of the legal aspects of the different engineering fields. A case, settled but a few days ago, in which one firm was made to pay damages amounting to several hundred thousand dollars, shows very clearly that this need is by no means mythical and that engineers, especially those who supervise the production of "dangerous substances," must understand to what extent they are liable for any damage to their customers.

The case in point involved the use of oxygen under very high pressure in the burning of lead for storage battery plates. The company supplying the liquid oxygen designed and installed a steel manifold into which ten tanks discharged simultaneously. This apparatus worked for a week—a remarkable circumstance, considering that oxygen expanding adiabatically can attain a temperature of 1,700° and that steel will burn in oxygen at 1,200° under 2,000 pounds pressure—and then exploded causing the destruction of the entire plant.

The defense showed that the use of a drilled steel manifold for supplying oxygen was the common practice of the industry, but the attorneys and technical experts for the plaintiff proved that companies selling a substance classed as "dangerous" did not fulfill their obligations towards their customers when they merely followed the standard practice but they must use every available means to secure the safety of that customer. In the present case, if copper or brass manifolds had been used instead of steel, this degree of precaution would have been exercised.

Numerous other cases of equal importance could be cited in which firms, have sustained heavy losses through the lack of legal knowledge on the part of their engineers. The law in its entirety is a profession in itself but any engineer can acquire sufficient knowledge of its relation to his particular field to protect both himself and his employer.

MATCHES AND CONSERVATION

At present, a logging railroad, thirty-two miles long, is in process of construction between Ohio Junction, Idaho, and the heart of the Coeur d' Alene National Forest and will be completed in a few months. The cost of this railroad will be $1,000,000 and it will transport yellow pine from the national forest to the main line railroad. Eighty million board feet are to be cut for use in making a portion of the matches used by American smokers.

This development is only one of a large number controlled by the match companies of this country and its magnitude might well cause amazement at the terrific expense of using wooden matches. Millions of board feet of yellow pine are being removed from our fast dwindling forests every year and no attempt is made towards reforestation. However, if the match industry were the only one cutting into the timber supply, we should have little cause for worry. But its consumption is extremely small compared to that of the paper or building industries. Northern Wisconsin is an example of the way private corporations exploit large forests. Miles upon miles of desolate, burned stumps remain as a monument to inefficiency and greed.

It is surprising that any of the national forests would be leased to private corporations for the removal of stumps and for replanting. At the present rate of consumption, we shall see the day when all our timber is gone unless the government compels reforestation on public lands or substitutes are found for woolen products.

TECHNICAL TRAINING

With the increased use of scientific principles in all industries, a greater demand has arisen for skilled workmen. Employers are awakening to the fact that it is unusually cheaper to hire highly trained men at increased wages and eliminate costly inspection and loss of trade, due to non-uniform product. To satisfy this demand, trade schools have been established in all large cities to supplement the practical training of the apprenticeship.

The training of an apprentice has always been a somewhat haphazard and costly procedure—costly at least for the employer. It is carried on by master workmen who probably know very little of the principles involved.

To promote this desirable high standard of intelligence and workmanship, the employers and the sheet-metal and lathe workers unions of Pittsburgh have signed an agreement regarding the training of apprentices. It provides that during the last four years of his apprenticeship, every apprentice shall attend class one day a week at the Carnegie Institute of Technology. He is to be paid his regular wages by his employer for the time he spends in class. The courses of study include geometrical drawing, mathematics and pattern design. Such a contract is unique in the relations between capital and labor, but it shows that both are becoming aware of the necessity for technical training for practically everyone engaged in industry.

Good news for all lovers of graphic pie

Graphic pie enough to satisfy the hunger of a life-time; no end of graphic mountains to scale and toboggan down. That's what the man who loves to analyze graphs and statistical symbols can look forward to when he comes with the electrical industry.

Economic study is one of many branches in this broad field. If you have thought of electricity as limited to engineers, this other side of the picture will interest you.

The commercial organization with its problems of distributing, selling, advertising; the manufacturing end with its opportunity for trained technical men; the legal and accounting branches—all this and more totals electrical industry.

It may pay you to keep this in mind against graduation.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

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Number 43 of a series

THE SWIMMING POOL AND THE ENGINEER

(*Continued from page 169*)

Before describing the device for automatically "emptying, scrubbing and refilling" let us consider the question of gutters. Everyone who has used a swimming pool has, no doubt, noted that a pool gutter is never more than a side pocket which invites spitting but which repeatedly empties back into the pool after being filled by a wave. The proper gutter is one which empties all along its length, side-wise, into an adjoining filter bed.

The automatic "emptying, scrubbing and refilling" device

A light bulkhead spans across the pool like a water gate. The bottom and ends of this bulkhead have a canvas "shoe" enclosing an "inner tube" like an automobile tire. The "inner tube" is filled with water. This "inner tube" and canvas "shoe" fit snugly against the bottom and sides of the pool, forming what may be called a squeegee cushion. The bulkhead stands at one end of the pool while the pool is in use; when at the deep end of the pool it is left in the pool, but when at the shallow end of the pool it is hoisted by two small tackle blocks which are attached to two hinged brackets and swung flat against the end of the room or pool enclosure. It takes one man 40 seconds to hoist the bulkhead and swing it into this out-of-the-way position, and an equal time to replace it in the pool.

The pump delivers pure water back of the bulkhead as the bulkhead stands at one end of the pool and this pure water flows across to the opposite end of the bulkhead and through openings or ports in the bulkhead into the pool. When the pool is not in use, from noon to 2 P.M., for example, in a heavily patronized public pool, the end wall of the pool and the back face of the bulkhead are swabbed by hand, the bulkhead openings are closed, and the bulkhead is then pushed along by the fresh water. A maximum difference of level of three-fourths inch front and back of the bulkhead is sufficient to push the bulkhead along and as the bulkhead is pushed along it scrubs the bottom and side walls of the pool. Not a drop of the old water in the pool can ever pass the bulkhead and mix with the pure water behind the bulkhead. When the bulkhead has traveled the full length of the pool an automatic device stops the motor which drives the pump, and safety devices are provided to prevent damage to the bulkhead in case the motor-stopping mechanism fails to function or in case the attendant who puts the mechanism into operation carelessly neglects to open and close the proper gates. The bulkhead is arranged to travel from the deep to the shallow end of the pool, and then from the shallow to the deep end alternately.

The bulkhead-controlling mechanism consists of two heavy sliders (100 pounds each) which slide alongside of the pool (one on each side of the pool). Each slider has two attached fingers which engage the end posts of the bulkhead and hold the bulkhead in a vertical position, and a ¼-inch galvanized sash cord arranged in a well-known manner is attached to the sliders so as to constrain the sliders to move at the same speed, thus holding the bulkhead squarely across the pool. The sliders and rope can be brought from a storage closet and arranged for service by one man in five minutes, or taken away and stored in the same length of time.

Cost of New-Style Pool as Compared with Old-Style Pool

The following estimates refer to a pool 25 feet wide by 100 feet long, with an average depth of five feet and holding 100,000 gallons of water. The N pool is assumed to have filter and pump capacity sufficient to turn over the contents of the pool in eight hours so that the "emptying, scrubbing and refilling" operation can be performed every night; the O pool is assumed to be actually emptied, scrubbed and refilled once a week and to have filter and pump capacity sufficient to turn over the contents of the pool in 24 hours; both pools are assumed to be used four hours per day for six days a week; filters and pumps are assumed to be operated at full capacity while the pools are in use; and in the case of the N pool the filter and pump are assumed to be operated eight hours each day when the pool is not in use.

We will consider only differences in costs, neglecting items of cost which are the same for N pool and O pool such as water and heat for showers, heating of building, etc. Also we will assume coal to be $8 per ton and electrical energy to be five cents per kilowatt-hour.

It is common practice to use chemical disinfectants in the O pool, but chemical disinfectants cannot be used in the N pool because disinfectants inhibit the necessary bacterial action in the sand filter.

First cost. The filter bed for the N pool is half as large as the pool in area, and pool walls and building walls are utilized as filter bed walls. Therefore, we may charge about two-thirds of the cost of filter bed walls and the whole of the cost of the platform which covers the filter bed to the pool as if it were an O pool. This leaves about 80 cubic yards of concrete as chargeable against the N pool for division walls, side walls and bottom of filter bed and at $10 per cubic yard this amounts to $800. Also we must have 180 cubic yards of filter sand and gravel at $3 per cubic yard, and we must have the bulkhead mechanism and appliances for cleaning the filter bed which will cost together about $350. Therefore, the excess cost of the N pool will be about $1,700, which at 7 per cent interest and depreciation per year amounts to $2.97 per week for 40 weeks each year.

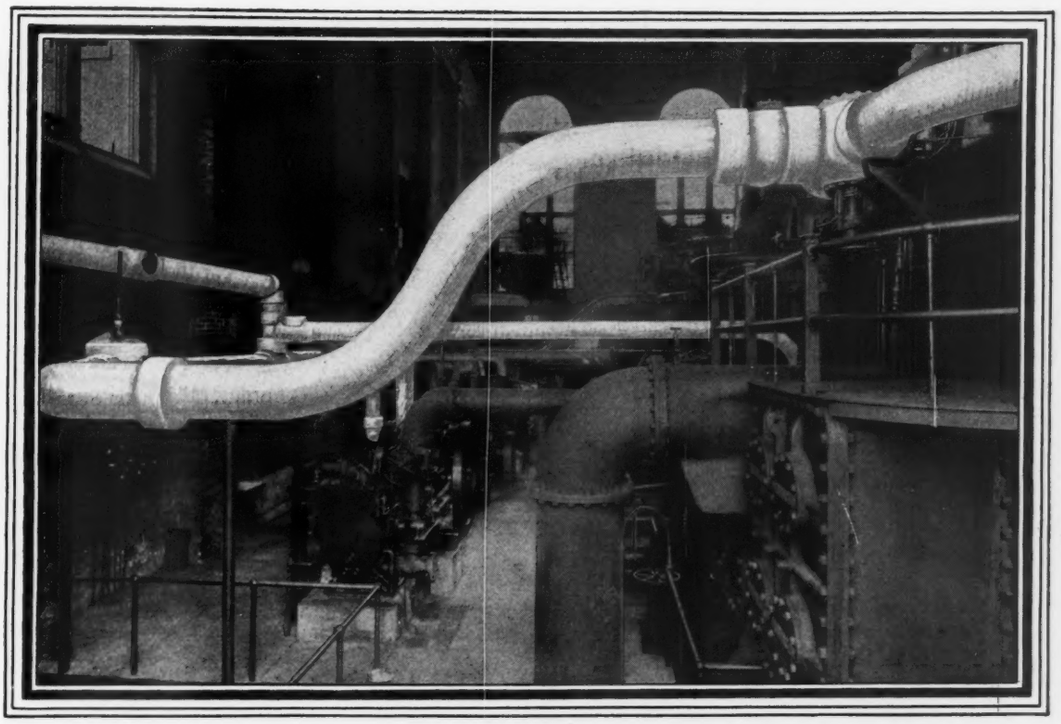
Labor cost. The emptying, scrubbing and refilling of the O pool involve a great deal of labor, and this labor, together with the care of the usual old-style pool equipment, is certainly greater than the labor required by the new-style pool. However, we will assume the labor costs of N pool and O pool to be the same.

Water cost. A recently constructed pool in Bethlehem, Pennsylvania, an old-style pool, buys city water at 7½ cents per thousand gallons, and during the winter months this water is at 40°F., or, let us say at 50°F. during the 40-week school season. To heat the water to 75°F. costs 10 cents per thousand gallons with good coal at $8 per ton. Therefore the actual cost of water is 17½ cents per thousand gallons, and the weekly consumption of water, with one emptying, scrubbing and refilling per week (100,000 gallons) and 2,500 gallons gutter loss per day, is 115,000 gallons which amount to $20.12 per week.

The only steady demand for water by the N pool is for flushing the filter beds once in 16 weeks, and about 100,000 gallons is required for each complete flushing (which incidentally provides for the discarding of the repeatedly filtered pool water). Therefore the water consumption of the N pool is 6,250 gallons per week which at 17½ cents means a weekly cost of $1.09. The gutter flow of the N pool passes directly into the filter.

Energy cost. Each turnover of the pool water of the N pool (3-foot pump lift) takes 2 kilowatt-hours and costs 10 cents. Each turnover of the pool water of the O pool (20-foot pump lift) takes 13.33 kilowatt-hours and costs 66 2/3 cents. Therefore with 1½ turnovers per day for the N pool and 1/6 turnover per day for the O pool the weekly energy costs are 90 cents

(*Continued on page 188*)



PIPE BENDS GET AROUND MANY DANGER POINTS

Good pipe-line engineering employs pipe bends in many places in preference to elbow fittings and expansion joints.

In steam lines which feed reciprocating engines, for instance, the pulsating flow of steam makes the use of pipe bends at right angle turns almost imperative to avoid hammering. In straight runs of piping subject to temperature variations, pipe expansion bends are the most satisfactory means of taking up expansion and contraction.

Pipe bends of any form reduce the strains which are usually the cause of leaks at joints. They must be properly designed, however, and made to fit into place without forcing. Otherwise dangerous strains may be set up in them, completely offsetting the advantages derived through their use.

Investigations carried on by Crane Co. have uncovered much information of value about pipe bends. The results are summed up in complete data tables that form an interesting chapter of Crane catalog No. 51. If this book is not in your files, we will be glad to mail you a copy on request.

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THE SWIMMING POOL AND THE ENGINEER

(*Continued from page 186*)

for the N pool and 66 2/3 cents for the O pool.

Summary of costs. Summing up the above items we find that it costs $15.73 *more* per week to operate the O pool than to operate the N pool in spite of the fact that the N pool is "emptied, scrubbed and refilled" 6 times as often as the O pool and in spite of the fact that fresh water is circulated through the N pool while it is in use three times as fast as through the O pool.

The Outdoor Summer Pool. The writer is a great believer in the outdoor summer pool, especially in the prosperous cities and towns in the West and South where there are no natural facilities for swimming and where the summers are long and hot; and the writer believes that swimming pool facilities for such cities and towns can be provided best and most cheaply by a commercial development of the outdoor summer pool. Indeed, the important features of the new-style pool as here described have been covered by United States patents in order to encourage a commercial development of this kind.

Surely we Americans can afford the things we need, and the American slogan should be, "Pay for what you get, and get what you pay for!" The development of city-owned swimming pools is hopelessly slow and the management of the municipal pool is apt to be outrageously inefficient. In a municipal undertaking we may get a little that we do not pay for, but nevertheless in the end we pay a very great deal and we do not get what we pay for!

But cleanliness in a heavily patronized public pool of the old style is an impossibility, although dangers of actual infection can no doubt be eliminated by generous use of chemical disinfectants. A more attractive scheme would be to use the new-style pool brought to the condition of a clean glass of drinking water at 8 A.M., at 2 P.M., and at 8 P. M., with drinkable water circulated through the pool at a two-hour rate while it is in actual use.

The possibility of doing all this at a low cost gives the writer a vision of a chain of swimming pools surpassing as a mere business the biggest chain of grocery stores! An initial capital of $50,000, a franchise to build a summer pool installation on the choicest spot in the park system of a favorably located city, the sale of 6 per cent bonds locally to bring the capital up to $100,000, two afternoons a week at a very low charge in lieu of ground rent and taxes, a net profit of ten or fifteen thousand dollars a year, all of which above 6 per cent on the initial investment being devoted by the terms of the franchise to the development of the chain, and where would things stand after ten or fifteen or twenty years! The writer's interest in this matter is that of the playground enthusiast, and the patent rights of the new-style pool will be turned over without charge to any responsible corporation which will undertake even to make a critical study of the proposal. Must we American's always rely on fakirs to cater commercially to our recreation needs?

SOME PROBLEMS IN OIL ENGINE DEVELOPMENT

(*Continued from page 179*)

Every system of machinery has a natural period at which it will vibrate, as is true of a violin string or tuning fork. In the case of rotating machinery, however, the vibration under consideration is an oscillation forward and back, in the path of motion, of one part relative to another. As in the case of the violin string the machinery may vibrate in one or more nodes. Again, in the case of the violin string a shortening, lengthening, or increase in its diameter alters its period of vibration. Likewise in a system of machinery the addition or removal of a section of shaft, as well as changing any shaft diameter, alters the period of vibration. Another consideration which has an effect on the period is the size and position of the rotating masses of the system. An alteration of either changes the period.

These are the fundamentals of the theory of torsional vibrations which are used today to calculate the natural period of vibration of a system. This is done when an installation is in the design stage. Say this is found to be 1,200 oscillations per minute. Then if the prime mover be a four-cycle Diesel engine of eight cylinders, developing its power at 300 R.P.M., we find that since there are four impulses per revolution, or 1,200 per minute, that the rate of application of the power impulses coincides with the natural rate of vibration of this system. This engine then at 300 R.P.M. would be in a critical or synchronous speed which would probably be destructive, while if it had been rated at 10 to 15 revolutions lower and not run above that point the critical speed would never have been found. This, then, is the reason why torsional vibrations have been called a fault of the high speed engines of today. The former engines and their systems of shafting, generators, etc., had their natural periods, but because of their slow speed and small number of cylinders the rate of impulses was not high enough to coincide with them, and they were not known to exist.

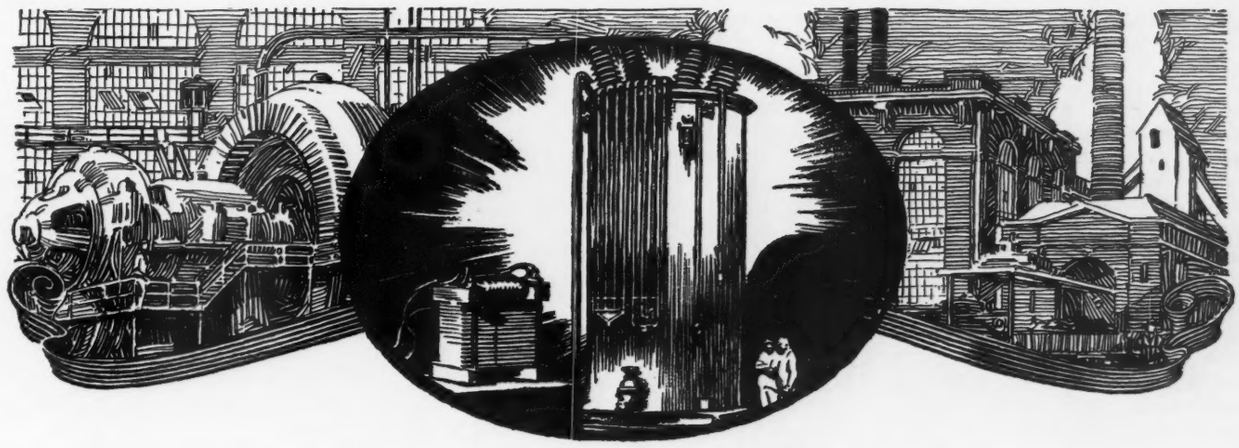
After finding the natural period of a system is such that it will be encountered in the operating range, changes in design are made to either drop it below the range or raise it above. This may be done in any of the ways mentioned above; that is, by reducing or increasing the diameter of the shafting, or by changing the mass of the revolving weights or their location.

Along with the location of the point or points at which synchronous speeds occur calculations are made to determine the severity of the vibration, for some may be so slight that a modification of the design is not warranted. These steps are all taken while the machinery is yet on paper, and then an added precaution is taken after the machinery is built.

Dr. Joseph Geiger of Germany has developed the torsiograph which is a machine designed to show graphically the variation in movement of any rotating member. With the help of this the manufacturer makes a careful study of the installation. The torsiograms taken at various points of a system of shafting show the motion at one point relative to another, the rate of oscillation, and the amplitude of the oscillation.

Then today if a system of machinery is carefully calculated to avoid critical speeds and the torsiograms do not show any, the manufacturer does not worry about fractures.

The above are but a few of the difficulties encountered in the development of the Diesel engine, stated very briefly. There are many more that have been overcome, and many more that will be overcome before the oil engine takes its place, as it surely will, in the automobile and railway locomotive.



A Toy—a Tool

THE first twenty days in December witnessed a big event in one man's life. They saw a toy grow into a tool—one of the most useful in all history.

On December 1st, 1885 there was brought to George Westinghouse, at Pittsburgh, an uncommercial "secondary generator"—a scientific toy. Westinghouse and associates lived with it day and night, and by December 20, 1885, in a flash of genius, had completed the essential conceptions of the modern transformer. Thus in twenty days they paved the way for alternating current, and the electrical era of the twentieth century.

Here was a brilliant engineering feat—a feat that through the years has been a particular inspiration to a specialized group of "design engineers" within the Westinghouse organization. These men are electrical and mechanical engineers who are attracted not merely by an engineering problem—but by the technical difficulties of "licking" that problem to narrow and exact practical limits.

These men work continuously with both sides of an equation. On one side are the needs of a customer. For the other side must be developed apparatus which exactly meets those needs. The apparatus may range from a complete system of electrification for a railroad to a new type of curling iron.

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WATER POWER DEVELOPMENT IN THE UNITED STATES

(*Continued from page 181*)

mines could not be transmitted to distances greater than about 200 miles and compete with power locally generated.

The advantages of the super-power idea have been so obvious that much progress has already been made in the fundamental requirement of interconnection of transmission lines and to some extent in the construction of large central steam plants. Thus, in New England, interconnection is already fairly complete for the southern New England States and connections now extend through to Niagara Falls on the West. In the Southern States similar progress has been made and the five large power companies are already interconnected. In the Central States the same movement is taking place, and also in California and its general vicinity. Incidentally, this movement is directing attention to the desirability of more comprehensive water power development and especially the value of secondary water power when tied in with a large transmission system.

American hydraulic turbine manufacturers now lead the world in all respects, — in output and size of wheels, as well as efficiency. It is now the common thing to find turbines giving over 90 per cent efficiency and even 93 to 94 per cent has been reached in some cases. Wheel settings have also been greatly improved and simplified during the past decade, the best practice now for reaction wheels being the use of a single-runner vertical unit with concrete or steel spiral flume. Much study and experiment have also been given to draft tube design, resulting in the hydraucone and spreading types of tubes, which help to minimize velocity exit losses.

In Fig. 1 is shown a recent wheel setting with Moody spreading draft tube as constructed by Wm. Cramp & Sons Co., I. P. Morris Dept. This wheel is also of a comparatively new design,—called the propeller type; an axial flow wheel of specific speed much above that of the ordinary reaction wheel, but nevertheless holding up well in efficiency.

In Fig. 2 is shown a shop view of one of the impulse or Pelton wheels constructed by Allis-Chalmers Co., for the Caribou Plant on the North Fork of Feather River, Calif. These are double overhung units of 30,000 H.P. capacity acting under 1,008-foot head (the largest impulse wheel units now in use)—the wheel being 13 feet in diameter and the jet of water from the nozzle measuring 11 inches in diameter.

Construction costs are slowly lowering—the present index figure is about 205 per cent (of 1913 costs), as compared with 220 per cent a year ago and 274 per cent in the peak of 1920. Fuel costs still remain relatively high, due largely to the cost of transportation. Our perspective of the relative dependability of steam and water power was much altered in the times of fuel shortage during and just after the war—due to both labor and transportation troubles. The coming years are likely, therefore, to see widespread water-power development, in the districts where it is available.

Only Thirteen Airplane Engines, rated at 600 horsepower or over, have actually been designed and built. Seven were of French design, three were British, two American and one Italian. Apparently only six of these engines have been developed to any great degree — three British, one French, one Italian, and one American.—*American Machinist.*

TECHNOLOGY BRANCH H. C. S.

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This remark is credited to a former Technology professor in the Civil Engineering Department.

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Pender's Handbook for Electrical Engineers	6.00
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THE VERSATILITY OF X-RAYS

(*Continued from page 177*)

plete ones until once more the usual progression is again re-established.

34. *The Number of Electrons in Atoms and the Existence of Ions or Atoms in Space Lattices.* From scattering experiments, together with Thomson's classical equations, Barkla many years ago found that the number of electrons is equal to half the atomic weight. This is true for the lower atomic numbers, but departure from the classical conditions of non-co-operation of electrons in X-ray scattering renders the relationship less and less accurate with higher atomic numbers. The intensities of reflection of characteristic lines is also a medium for evaluation of the number of electrons. Upon this basis Debye declared that lithium hydride in its lattice was composed of lithium and hydrogen ions. Recent work throws considerable doubt upon the general truth of this observation. Professor Bergen Davis of Columbia University has made the interesting discovery that experimental results on refraction of X-rays in pyrites and other crystals when applied in the dispersion formula of Lorentz give values for the number of electrons in various levels, which are the same as postulated by the Bohr theory.

35. *The Quantum Theory.* The Bohr theory of atomic structure and of the production of radiation has the quantum theory, or the discontinuity of energy changes, as a foundation stone. The combination principle substantiates it. Even more direct evidence of its validity is contributed by X-rays; for the short wave-length limit of the general radiation from a target is absolutely sharply and perfectly defined by the quantum equation $Ve = h\lambda = hc/\mu$ where V is the voltage applied to the X-ray tube, e is the charge of the electron, h is Planck's action constant, λ the frequency, c the velocity of light, and μ the short wave-length limit. Furthermore, the phenomenon of interference in reflection from crystals, long considered possible only upon the wave theory conception, is now explained by Professor Duane of Harvard upon a quantum basis by quantizing radiation momenta transferred to matter. The great controversy between proponents of the classical electromagnetic theory and those of the quantum theory still rages with the present tendency towards uniting the old and new theories and casting out bodily the discrepancies. Two years ago A. H. Compton announced a theory of the scattering of X-ray quanta by single electrons, which recoil resulting in the probability that the scattered X-ray has less energy by the amount involved in the recoil and hence a longer wave-length than the primary. This has been disputed by Clark and Duane who were unable to obtain evidence of the shift, but did discover tertiary X-rays produced by the impact of secondary photoelectrons on neighboring atoms whose short wave-length limit again is governed strictly by quantum laws. Much experimental work remains to be done relative to details, but the validity of the so-called "bullet" conception of radiation seems well established largely through the facts of researches with X-rays.

36. *Relativity.* The fine structure of X-ray spectra, for example, the L-doublets, agrees with theoretical considerations based upon the relativity theory. The change in mass of the electron with velocity is a generally accepted fact in all mathematical derivations.

37. *The Nature of Light.* Since the beginning of man's life on earth light has been recognized. Through the centuries philosophers pondered over it, mathematicians calculated it, physicists experimented with it. Now we find ourselves working backwards from the thirty-year-old science of X-rays to try to explain it—to interpret its structure and to trace its origin. There are now almost no experimental gaps at all in the long continuous series from the very long electric waves to the very short X-rays from radioactive substances.

The kinship is shown in the table A, in which the first column presents the type of radiation; the second, the frequency of vibration per second; the third, the wave-length; the fourth, the quantum voltage required for generation, and the fifth, the speed of the photoelectrons ejected from matter as a result of radiation impact.

Thus we have reviewed thirty-seven, by no means all of the achievements of the peculiar radiation discovered one day in the autumn of 1895 by Roentgen in his darkened laboratory, when his eyes beheld a barium platinocyanide screen strong luminescent. We have seen much of this mystery become clear fact under the hands of Barkla, Laue, the Braggs, Moseley, who fell

(*Continued on page 194*)

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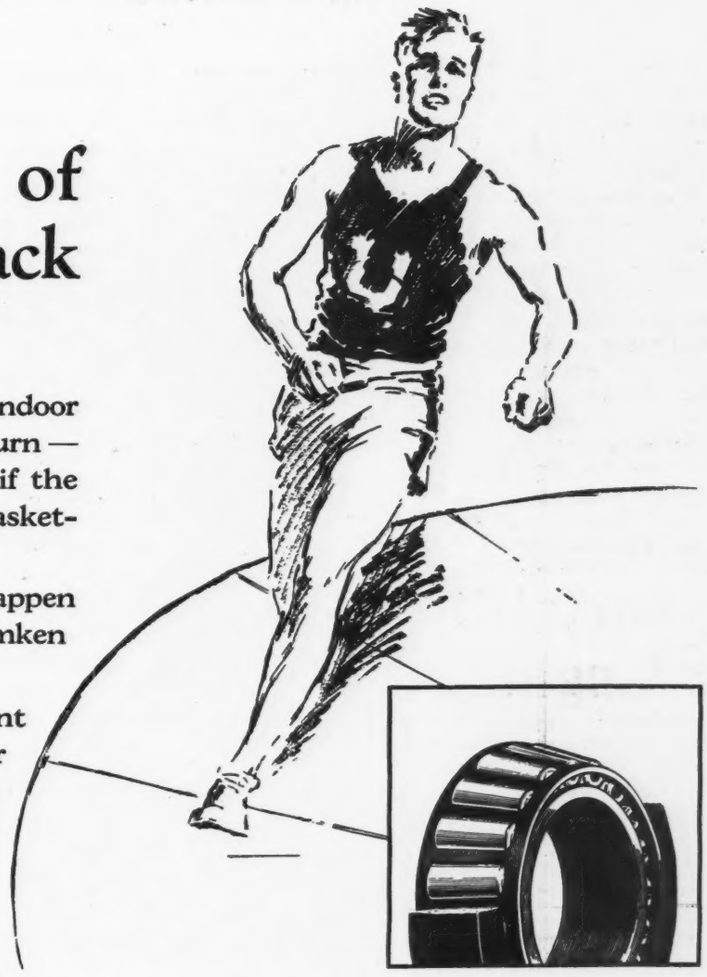
So the Turns of an Indoor Track are Banked



DOWN the stretch of an indoor track, then 'round the turn — what would happen to a runner if the turn were perfectly level, like a basketball floor?

The same thing that would happen to a Timken Bearing if the Timken Bearing were not *tapered.*

When you sharply turn the front wheels of a moving motor car, for example, the same thing happens as when a runner dashes round the turn of a track. The front wheels direct the car around the turn. Momentum, however, tends to throw it sidewise — in the same direction that it previously was traveling. The result is a heavy side load or "end thrust" on the bearings in the front wheels.

The bank of the track keeps a runner from feeling the effect of side-swing as he rounds a curve. A similar device — the taper — enables a Timken Bearing easily to withstand "end thrust" from any source.

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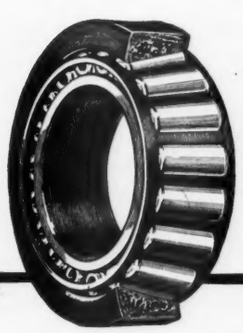

TIMKEN
Tapered
ROLLER BEARINGS

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THE VERSATILITY OF X-RAYS

(*Continued from page 192*)

for his England in the Dardanelles, Siegbahn and all the other experimenters, who, bit by bit, have built up our present knowledge. Who would have dreamed in 1895 that in 1924 great hospitals, dental laboratories, government arsenals, university departments of physics, chemistry, engineering, metallurgy, biology and medicine, factories producing sulfuric acid, or sheet metal, or paper, or bridges, or automobile tires, or chemicals, customs houses, detective agencies—all would have X-ray laboratories working at top speed? Whither shall the science of X-rays have led us in another thirty years?

TABLE A

Radiation	Frequency (Sec.$^{-1}$)	Wave-Length	Quantum Volts	Speed Photo-Electrons cm./sec.
Electric	10^{6}	3×10^{4} cm.	4.1×10^{-9}	3.8×10^{3}
Infra-red	10^{13}	$3 \times 10^{-3} = 30\mu$	4.1×10^{-2}	1.2×10^{7}
Yellow	5×10^{14}	$6 \times 10^{-5} = 0.6\mu$	2.06	8.5×10^{7}
Extreme Ultraviolet	3×10^{15}	$10^{-5} = 0.1\mu$	12.4	2.1×10^{8}
Very soft X-rays	3×10^{17}	$10^{-7} = 10A°$	1240	2.1×10^{9}
X-rays	3×10^{18}	$10^{-8} = 1A°$	12400	
Hard X-rays	3×10^{19}	$10^{-9} = 0.1A$	124000	Approach light
V-rays	10^{21}	$10^{-10}A$	10^{6}	Approach light

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RECENT BOOKS

(*Continued from page 182*)

Fats: Natural and Synthetic. By W. H. Myddleton and T. H. Barry, London: Ernest Benn, 1924. 182 pp.

After an examination of natural oils, fats and waxes and the fatty acids derived therefrom, and of the processes of oil extraction and purification, the book deals with the conversion of liquid oils into solid fats by catalytic hydrogenation. The uses of synthetic fats in the manufacture of soap, candles, margarine, chocolate, and baker's shortening, are described, and the difficulties encountered are considered. There is a comparative examination of natural and synthetic fats, with tables of analyses showing the differences in chemical composition.

Reinforced Concrete Design. By G. P. Manning. London: Longmans, Green & Co., 1924. 476 pp.

This work, says the preface, aims at establishing methods of design suitable for use in a civil engineer's office. Each problem is first viewed from the accepted theoretical standpoint; allowances are then made to adjust this academic treatment to the practical material, and finally the results are reduced to simple numerical factors for practical application, illustrated by examples. Author believes in the shortening and simplification of processes and formulae, for the attainment of speed, accuracy and economy. While citing the usual theory of elastic structures he points out that it does not apply exactly and furnishes only a very rough indication of the stresses in actual structures as built.

Essentials of Applied Calculus. By Robert Gibbes Thomas, Professor of Mathematics, Military College of South Carolina. New York: D. Van Nostrand Co., 1924. 408 pp.

Abridgment and re-arrangement of the material originally presented in 1919, covering elementary calculus in a more simple and understandable way than most college text-books. A portion of the book is given over to practical applications of calculus to problems in pressures, gravitation and ballistics.

The Kinetic Theory of Gases. By Eugene Bloch, Professor at the Lycee St. Louis. London: E. P. Dutton & Co., 1924. 157 pp.

A mathematical treatment of the general theory of gases with particular regard to the phenomena of viscosity, diffusion, specific heat, perfect gases, and the Brownian movement. Translated from the French by P. A. Smith, Oxford.

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We shall always remember the part played by the pioneers of the West in the building of our reputation, as well as in the development of America's mining industry.

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Wilkes-Barre, Pa.
Wilmington, Del.

THE INSTITUTE OF OPTICS AT PARIS

(*Continued from page 173*)

work done at the Optical Institute), and for all information concerning optics. This review is published in French but has already received contributions from other countries which have been translated into French before publication.

So far we have given a general outline of the present status of the Optical Institute. A few words can now be said about its administration, resources, and its future.

In France the majority of the scientific institutes are pure state institutions. The Optical Institute has been organized in a rather special way, which has already served as model for other institutions. The Optical Institute receives an appropriation from the state; it is connected with the University of Paris, which is a state institution, but it is not a pure state institute. It is administered by a council consisting of representatives of the state, of industry, and of science; it controls its own financial administration. The cost of installation was covered by gifts (about 600,000 francs); the annual expenses are covered partly by gifts, partly by the income of the Institute, and partly by the state appropriation.

Unfortunately, these resources are still insufficient. The annual budget only reaches 400,000 francs (about $20,000 at the present rate of exchange). The staff of the laboratory is insufficient; it only includes four graduate assistants who must be used for the preparation of the courses, for giving practical instruction to the students, and the carrying out of measurements and research in the laboratory. The building does not belong to the Optical Institute; it is a house with garden, quite unfit for its present use. The construction of a new building is under consideration, but only part of the necessary funds have been raised so far.

Notwithstanding the present meagre resources, some useful work has already been done; it is hoped that a greater amount of work will be accomplished in the future, and as all the results which are obtained are published, they will probably be generally beneficial.

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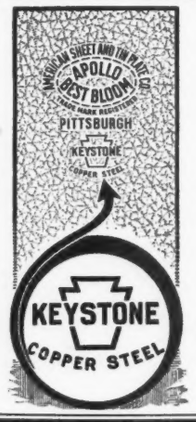

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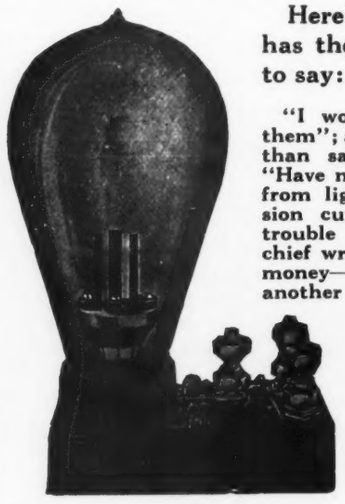

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"I would not do without them"; another writes, "More than satisfactory"; a third, "Have never had a fuse blown from lightning or high tension current"; another, "A trouble saver"; still another chief writes, "It has saved us money—fine results"; and another chief writes, "The installation has been very satisfactory. We have standardized on this equipment, and will equip any future installations in the same manner," etc.

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INDUSTRIAL LIGHTING CODES.

In order to protect workers from accidents and eye sight damage, no less than five states, New York, New Jersey, Pennsylvania, Wisconsin and Oregon have now in force lighting codes for industrial establishments. Other states are now considering the adoption of an industrial lighting code, and it seems only a question of time when all the states will adopt such a code.

Proper lighting of work places is not only of great importance to the operators working therein, directly affecting their safety and eyesight, but it is a factor of equal importance to the employer, as quality and quantity of output are deciding factors of profit or loss in the operation of the plant.

The introduction to the Wisconsin code reads as follows: "Insufficient and improperly applied illumination is a prolific cause of industrial accidents. In the past few years numerous investigators, studying the cause of accidents, have found that the accident rate in plants with poor lighting is higher than similar plants which are well illuminated. Factories which have installed approved lighting have experienced reductions in their accidents which are very gratifying.

"Of even greater importance, poor lighting impairs vision. Because diminution of eyesight from this cause is gradual, it may take the individual years to become aware of it.

"This makes it all the more important to guard against the insidious effects of dim illumination, of glaring light sources shining in the eyes, of flickering light, of sharp shadows, of glare reflected from polished parts of work. To conserve the eyesight of the working class is a distinct economic gain to the state, but regardless of that, humanitarian considerations demand it.

"Finally, inadequate illumination decreases the production of the industries of the state, and to that extent, the wealth of its people. Factory managers who have installed improved illumination, are unanimous in the conviction that better lighting increases production and decreases spoilage."

The Wisconsin Commission has adopted a rule to the effect that, "diffusive or refractive window glass shall be used for the purpose of improving day light conditions or for the avoidance of eye strain, wherever the location of the work is such that the worker must face large window areas, through which excessively bright light may at times enter the building."

A glass is now available which meets the above requirements. It properly diffuses the light and prevents sun glare passing into the building and is known as Factrolite.

Engineers of to-day are making a thorough study of illumination, so that they may be able to plan and lay out industrial plants, to scientifically increase their efficiency to as near the maximum as possible. This accomplished the engineer is not only doing something worth while for his employer, but is doing quite as much for himself by coming into prominence with modern ideas.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

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RECENT AERONAUTICAL EVENTS

(*Continued from page 171*)

definitely proven that an airplane can fly at more than four miles a minute around a closed circuit, and there is no reason to doubt that the figures can be raised to 300 miles an hour if efforts in that direction continue to be made. Efficiency can be demonstrated, however, and experiments in design and construction can be tried out, quite as well in lighter and slower machines. The thrill of competition is no less clearly present in a race between airplanes of limited engine capacity than in one subject to no limitation whatever, and the racing of airplanes is likely to follow the racing of automobiles in developing with a progressively stronger emphasis on competitions with small engines, although perhaps not quite as far down as the light plane class.

The national races have been of secondary importance among aeronautical events of the year. The outstanding achievement, of course, has been the world flight, but 1924 has been the year of the airship quite as much as of the airplane. The flight of the ZR-3, carried out in a reassuringly commonplace manner, as though there had never been any suspicion that anything could go wrong on such a trip, has been prophetic of a probable trans-Atlantic service by rigid airships. It is, in fact, understood that such a service is likely to be inaugurated by the ZR-3 in the very near future. The Atlantic has been crossed more than twice as often by airplane as by airship, but the traverse by heavier-than-air craft will always be a stunt without commercial significance, as substantially the full useful load capacity of the machine must be given over to fuel for the voyage, and the pay load would be impossibly small. The airship offers a very different outlook. It can easily be designed for a flying range of eight thousand miles, or even ten, and a flight from New York to Paris or from San Francisco to Honolulu can be made by such a ship as the ZR-3 with a passenger or express load aggregating several tons.

The future of air racing as a sport and a spectacle is shrouded in doubt. The Dayton meet is the greatest that has been held up to the present time, and it is easily conceivable that it may permanently retain that distinction.

The process of discovering new uses for the airplane, both in the service of peace and in that of war, which has gone on now for twenty years, will be continued without interruption, and the dependence of the community upon the services rendered by aerial transport, a dependence already, thanks to the air-mail's work, greater than many of us realize, will become progressively clearer. Air transport is constantly being improved in safety, in economy and in reliability. Its use cannot but increase.

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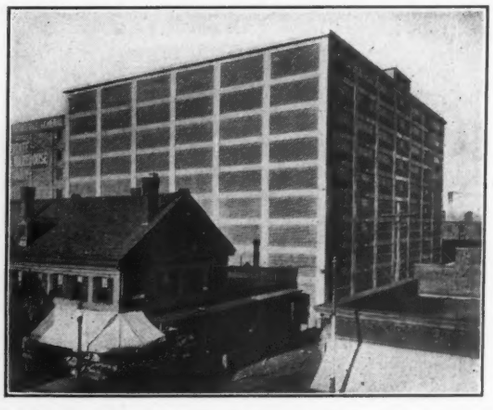

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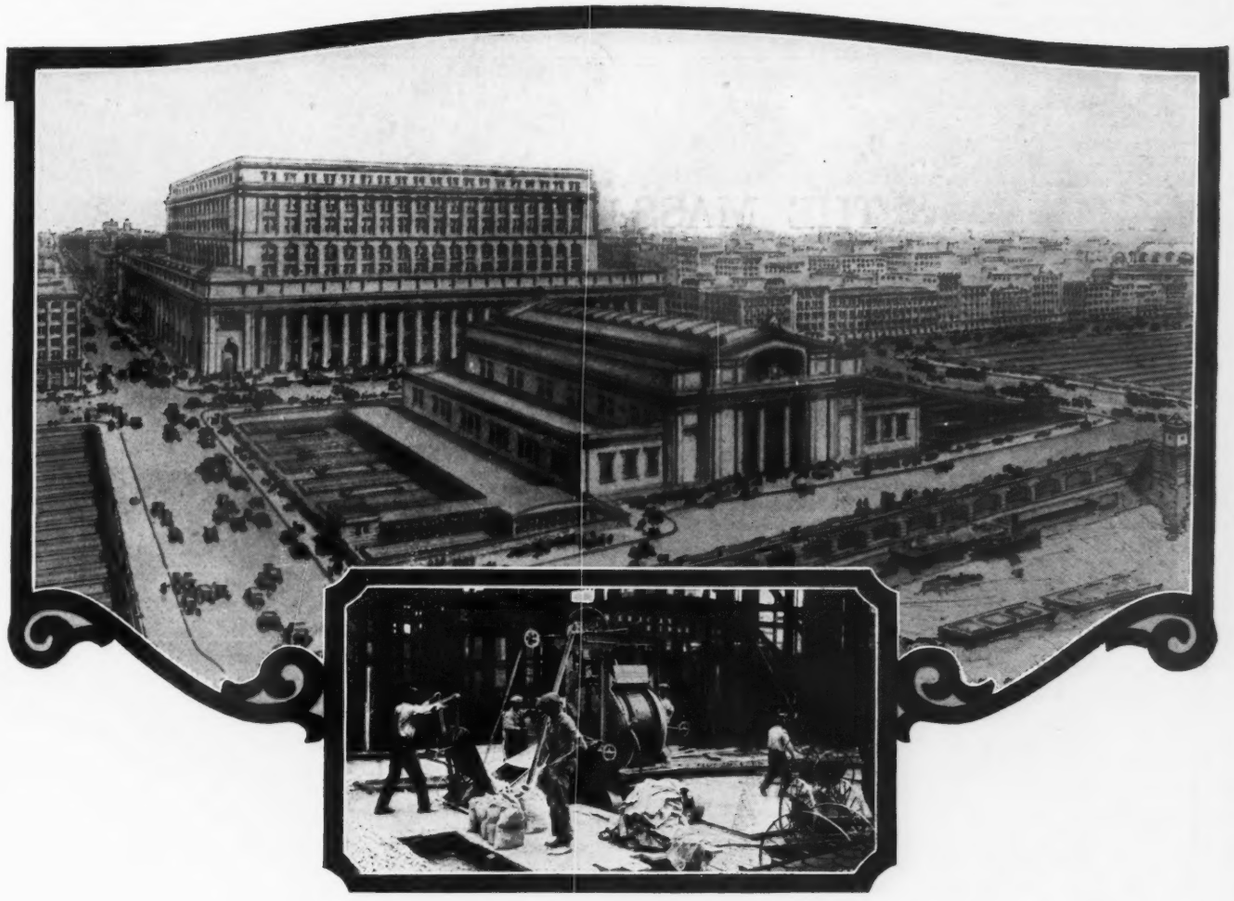

New Union Station, Chicago, and Koehring

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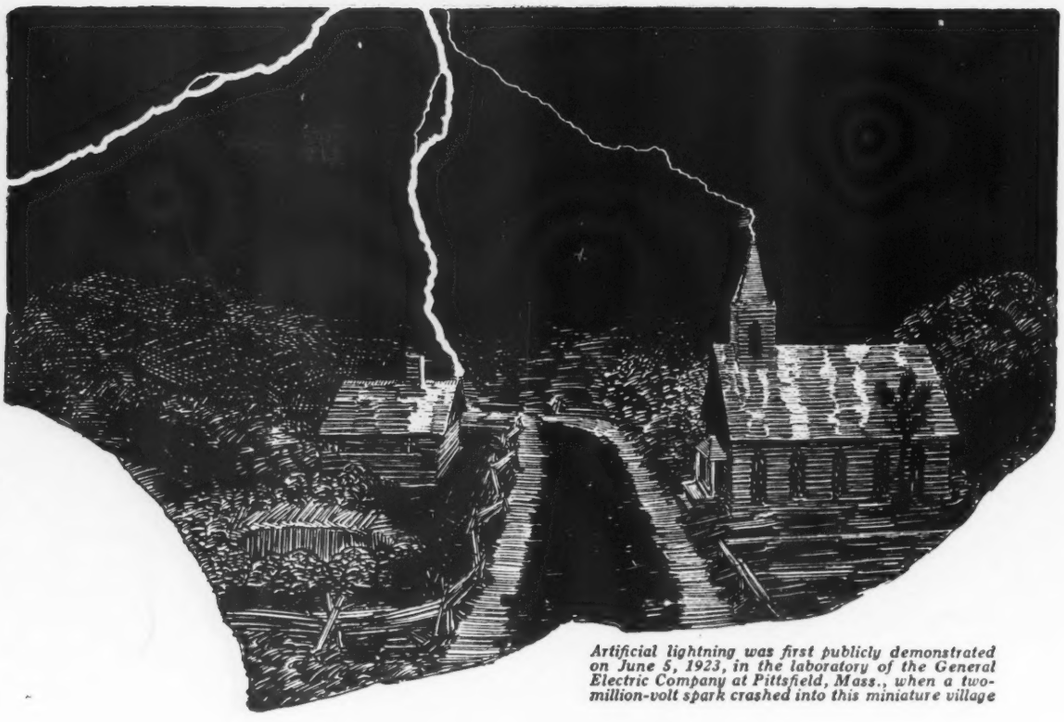

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